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ABSTRACT

Teachers from the United States and several other countries have access to the film library system of the National Aeronautics and Space Administration (NASA). This catalog contains the titles and abstracts for over 150 films that are available from NASA on topics regarding space flight, meteorology, astronomy, NASA programs, satellites, research, safety, technology, and earth sciences. Ordering and usage information are also included. A lesson guide is provided in the appendix to accompany 37 of these films. Each guide lists objectives, important vocabulary, preparatory activities, follow up activities, evaluation ideas, related information sources, and ideas for presenting the lesson. (CW)

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Film Catalog

John F. Kennedy Space Center

1987

SE 050 129

BEST COPY AVAILABLE

A catalog of films from Kennedy Space Center

Introduction

Residents of the United States, Canada, England, and the Netherlands who are bona fide representatives of educational, civic, industrial, professional, youth activity, and government organizations are invited to borrow films from a NASA Regional Film Library listed on page vi. There is no film rental charge, but the requester must pay return postage. Films are loaned for group showings and are not for screening before individuals or in homes. The films are to be shown only by a qualified projector operator. Because custody of the films involves both legal and financial responsibility, films cannot be loaned to minors. Size of all films is 16mm.

Residents of Florida, Georgia, Puerto Rico and the Virgin Islands should address requests to:

Film Library
John F. Kennedy Space Center, NASA
Kennedy Space Center, Florida 32899
Telephone: Area Code 305, 867-7060

To expedite film shipment, requests should list: (1) KSC number and title, (2) name, address and organization of requester, (3) desired showing date (with alternate date if appropriate), and (4) expected size of viewing audience(s). If film is not available when requested, a related film may be substituted.

Television stations may order films, unless otherwise noted, for unsponsored public service or sustaining telecasts. Stations are encouraged to transfer films to video tape and return them as soon as possible.

Also available for educational TV productions are 35-mm slides, an audio tape of space age sounds and 16-mm film clips on selected subjects. For further information, residents of Florida, Georgia, Puerto Rico and the Virgin Islands should write to Educational Programs Staff, Public Affairs Office, Kennedy Space Center, Florida 32899, or telephone (305) 867-4444. Residents of other areas should contact their Regional Film Library listed on page vi.

Films may not be cut without written permission from the Public Affairs Office of the Kennedy Space Center.

Lesson guides for selected films are included in an appendix to this film list. Such films are identified by an asterisk after the title both in the film list section and the alphabetical index.

Shown below is the audience report form included in every film shipment. The lower portion should be completed and returned with the film.

(Fill in as indicated)

SHIPPING DATE	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	ORDER NUMBER
6/10/83		E
SHOWING DATE	KSC FILM LIBRARY	CATALOG NUMBER
6/17/83		431
RETURN DUE DATE *	KENNEDY SPACE CENTER, FLORIDA 32899	COPY NUMBER
6/24/83	ATTN: EG&G 944.2	2

FILM TITLE: Apollo Mission Highlights

SHIP TO:

VIA:

MAIL [X]

PICK-UP [ ]

Joseph Media
Wildburg Middle School
3606 64th Avenue
Anytown, FL 39693

SAMPLE

NUMBER OF SHOWINGS **		EVALUATION		COMMENTS
TOTAL TIMES SHOWN		Excellent	☐	
TOTAL NUMBER VIEWING		Satisfactory	☐	
		Unsatisfactory	☐	

KSC FORM 18-204 (REV. 3/73)

SIGNATURE

IMPORTANT! PLEASE FILL OUT AUDIENCE REPORT AND RETURN WITH FILM

*"Return Due Date" is date film should arrive back at Library.

**Please make sure entries are made in both blocks.

Handling Notes

NASA films cover a wide variety of subjects related to aeronautics and space.

Please bear in mind that each of these films, regardless of subject, is a fragile item and must be handled carefully. Before each film was mailed to you, it was inspected, cleaned and repaired to make sure you received it in a usable condition. Help us keep it that way.

PLEASE...

- Use an experienced projectionist.
- Keep your projector clean.
- Never patch film – we'll repair it.
- Return leaders and tails even if damaged or torn.
- Prevent damage in the mail – tape loose end.
- Use only our prepared return mailing label.
- Use your return address.
- Rewind the film properly on the same reel on which it was received.

AND.

To avoid disappointing the next scheduled user, return film immediately after your scheduled viewing date.

To help us operate our film library efficiently, complete the "Audience Report" enclosed with the film.

Contents

	Page
INTRODUCTION	iii
HANDLING NOTES	iv
NASA REGIONAL FILM LIBRARIES	vi
FILM LIST	
General Interest	1
NASA Facilities	3
Mercury Program	4
Gemini Program	4
Apollo Program	4
Apollo Digest Series	5
Unmanned Lunar Missions	6
Skylab Program	6
Skylab Science	6
Space Shuttle	7
Astronomy	10
Communications	12
Meteorology	12
Mars Missions	12
Aeronautics	13
Life Support Systems	13
Navigation	14
Propulsion and Power	14
Research	14
Technical Science Subjects	14
Technology Utilization	15
Safety	15
Industrial Arts	16
Earth Sciences	16
APPENDIX A: Film Lesson Guides	19
ALPHABETICAL INDEX	99

NASA Regional Film Libraries

If You Live In:		Write to:
Alaska* Arizona California Hawaii** Idaho Montana	Nevada Oregon Utah Washington Wyoming	Ames Research Center, NASA Public Affairs Office, 204-12 Moffett Field, California 94035 Phone (415) 965-6270

*You may also request NASA films from: Alaska State Library, Pouch G, Juneau, Alaska 96801.

**You may also send your request to: The Department of Education, State of Hawaii, Office of Library Services, Support Services Branch, 641-18th Avenue, Honolulu, HI 96816.

Alabama Arkansas Iowa Louisiana	Mississippi Missouri Tennessee	George C. Marshall Space Flight Center, NASA Public Affairs Office, CA-20 Marshall Space Flight Center, Alabama 35812 Phone (205) 453-0040
Connecticut Maine Massachusetts New Hampshire Delaware District of Columbia	Maryland New York Rhode Island Vermont New Jersey Pennsylvania	Goddard Space Flight Center, NASA Public Affairs Office, Code 202 Greenbelt, Maryland 20771 Phone (301) 344-8101
Florida Georgia	Puerto Rico Virgin Islands	John F. Kennedy Space Center, NASA Code PA-EAB Kennedy Space Center, Florida 32899 Phone (305) 867-7060
Kentucky North Carolina South Carolina	Virginia West Virginia	Langley Research Center, NASA Langley Station Public Affairs Office, Mail Stop 145-B Hampton, Virginia 23365 Phone (804) 827-2634
Illinois Indiana Michigan	Minnesota Ohio Wisconsin	Lewis Research Center, NASA Office of Educational Services 21000 Brookpark Road Cleveland, Ohio 44135 Phone (216) 433-4000, Ext. 708
Colorado Kansas Nebraska New Mexico	North Dakota Oklahoma South Dakota Texas	Johnson Space Center, NASA PTD Audio Visual Services, Code JL3 Houston, Texas 77058 Phone (713) 333-4980

Foreign requestors may obtain information about the purchase of films by writing to the National Audio Visual Center (GSA), Washington, D.C. 20409. A few NASA films (in English or occasionally in a language version) may be available for loan from the United States International Communications Representative at the American Embassy in the national capital of the country. Requests for information about the loan of films should be addressed to the Public Affairs Officer at the American Embassy.

Selected NASA films may also be borrowed for a fee in the following countries from the listed film libraries:

National Film Library
75 Albert Street
Suite B20
Ottawa, Ontario, Canada K1P5E7

British Interplanetary Society
27/29 South Lambeth Rd.
London S.W. 815Z
England
(Great Britain Only)

**Supervisor, Educational Media Division
Department of Extension
The University of Alberta
82nd Avenue and 112th Street
Edmonton, Alberta, T6G 2E1
Canada

New American Film Library
Mr. Klaas Padding
Geestbrugweg 128
Rijswik (Z-H)
(Netherlands Only)

**Serves Western Canada and Northern Territories for 3-day bookings.

Film List

GENERAL INTEREST

STEPS TO SATURN
KSC No. 44 Sound, Color, 22 Minutes, 1967

From initial development of rockets, including the work of Dr. Goddard, through the development of Saturn.

YOUR SHARE IN SPACE
KSC No. 65 Sound, Color, 27 Minutes, 1962

Film deals with present and past success in the conquest of space. The theme around which the movie is built is "Using Space To Improve Life On Earth." In the field of communications, Echo I and II, and Telstar are illustrated and discussed. In the field of weather forecasting, the Tiros weather satellite and its importance in the forecasting of hurricanes is shown. Launches of manned shots and scenes of the astronauts in capsules are included. Possibilities in the fields of medicine are discussed. The film briefly touches on the flight and work being done in the X-15 Program, and the future implications and expectations of space flight and exploration.

THE JOHN GLENN STORY
KSC No. 97 Sound, Color, 31 Minutes, 1963

A biography of Mercury Astronaut John Glenn depicting his boyhood, his distinguished record as a Marine Corps pilot, his historic mission as the first American to orbit the Earth, his welcome home and his address before Congress. The late President John F. Kennedy introduces the film; Jack Webb narrates it. The film stresses American ideals and is highly appropriate for both youth and adult groups.

FATHER OF THE SPACE AGE
KSC No. 109 Sound, Black & White, 18 Minutes, 1961

The life and experiences of Robert H. Goddard, as told by his wife. Goddard pioneered the world's first liquid-fueled rockets. In 1929 his rocket soared for two seconds. His later rockets became a fire hazard. Goddard and his wife moved to New Mexico (not far from White Sands) where his work continued until the late thirties. This is an excellent film, Interest: Twelve years to adult.

BEFORE SATURN
KSC NO. 120 Sound, Color, 15 Minutes, 1964

The fascinating history of the development of rockets from the early Chinese up to, and including, the giant Saturn launch booster. Produced by NASA and Marshall Space Flight Center.

AMERICA IN SPACE
KSC No. 149 Sound, Color, 14 Minutes, 1964

A brief preview of NASA's first five years, showing the growth of the United States space effort from its beginning, ranging from Explorer I to the early phases of the program to land an American on the Moon.

THE NASA BIOSATELLITE PROGRAM
KSC No. 273 Sound, Color, 28 Minutes, 1965

Gravity – what are its effects on basic life processes? What will be the effect of prolonged weightlessness, particularly upon man? These are but a few of the questions investigated by the NASA Biosatellite Program. Leading biologists in the country have designed experiments that will investigate many of the basic processes of life. In this film, these biologists explain the various categories of experiments that will be conducted in an Earth-orbiting satellite, how they will be carried out, and the importance of seeking information about weightless atmospheres for scientific research and for the Manned Space Program.

ALL SYSTEMS GO
KSC No. 274 Sound, Color, 26 Minutes, 1965

Gives reasons for space exploration and historical aspects of space from Dr. Goddard and German scientists to manned orbital flights. It shows industrial complexes in operation prior to countdown. The film continues with requirements and reliabilities necessary to place a man in orbit. Tests give data and pose new questions, such as man in space, weightlessness, guidance, telemetry, launch and recovery, and propulsion (ion engine, nuclear energy). This film briefly explains the purpose of Telstar, Echo, Tiros, Mariner, and Gemini. (Narrated by Radcliff Hall and Bob Wilson.)

TRIAL BALANCE (REVISED)
KSC No. 319 Sound, Color, 28 Minutes, 1965

This fascinating and colorful film shows through the use of new graphic techniques how NASA has contributed to the growing body of scientific knowledge. The program explores such fields as meteorology, communications, the study of planets and the search for extra-terrestrial life. The film departs from the use of animation only briefly to include dramatic photos of the surface of the Sun and Moon. Although the film is ideally suited for educational purposes, it is non-technical and has a broad appeal to general adult audiences.

THE DREAM THAT WOULDN'T DOWN
KSC No. 333 Sound, Black & White, 26:48 Minutes, 1966

The dream of Dr. Robert Goddard, the father of U.S. rocketry, is explored and examined through the reminiscences of Mrs. Goddard. Included is historic footage of Dr. Goddard's early experiments and the personal commentary of Mrs. Goddard.

TO WORLDS BEYOND
KSC No. 388 Sound, Color, 28 Minutes, 1966

The film opens with the dreams and prognostications of French novelist Jules Verne with regard to space travel by human beings. It shows how such dreams were eventually shaped into reality. Gemini, Vostok, Mercury and Apollo spacecraft are discussed. The film culminates with a hypothetical journey to the Moon in a 3-man Apollo spacecraft.

AMERICA IN SPACE: THE FIRST DECADE
KSC No. 441 Sound, Color, 28 Minutes, 1968

A pictorial review of the American space program from 1958 to 1968. Illustrates briefly the major areas of accomplishment from the launching of the Explorer I satellite through the preparations for the first manned flight to the Moon, including NASA's role in aeronautical research, atmospheric studies, scientific and applications satellites, lunar and planetary probes and manned space flight. The film also stresses the contribution of industry, education and the scientific community to the aerospace program. Narrated by Alexander Scourby.

THE 50TH YEAR (A SPECIAL REPORT)
KSC No. 443 Sound, Color, 14:30 Minutes, 1968

The film traces highlights of aeronautical and aerospace research and development activities from 1917 through 1967, at NASA's Langley Research Center, Hampton, Va. This half-century overview documents major milestones in flight testing techniques from early biplanes to supersonic aircraft and spacecraft. The curator of the Smithsonian Institution narrates part of the film, referring to famous aircraft of the past housed within his museum. Famed World War II aviator General James H. Doolittle discusses how future supersonic commercial aircraft will affect this nation's passenger travel and economy.

WITHIN THIS DECADE: AMERICA IN SPACE
KSC No. 488 Sound, Color, 28:30 Minutes, 1969

This film presents a pictorial review of major accomplishments by NASA in space exploration and aeronautics from the establishment of the agency in 1958 through the Apollo 10 mission and preparations for the first manned lunar landing in 1969. Emphasis is placed on the contributions of the Apollo 8, 9, and 10 flights to the success of man's journey to the Moon. The film also reviews briefly the results of scientific satellites, communications and weather satellites, lunar probes, planetary research and aeronautical research.

MAN IN SPACE – THE SECOND DECADE
KSC No. 518 Sound, Color, 28 Minutes, 1971

The film shows manned space activities programmed, those under study and a look beyond the 1970s. Included is the Space Shuttle. Possible future programs illustrated include the Space Station, the Space Base, the Nuclear Shuttle, the Space Tug and manned interplanetary missions.

FROM BALLOON GONDOLA TO MANNED SPACECRAFT
KSC No. 520 Sound, Color, 27 Minutes, 1967

Three decades ago the brothers August and Jean Piccard were pioneers in both deep sea bathysphere exploration and early research flights into the stratosphere. Historical record of balloon flights emphasizes the early development and testing of environmental control systems. Narrated by Dr. Jeanette Piccard.

THE KNOWLEDGE BANK
KSC No. 524 Sound, Color, 25 Minutes, 1971

Details the accumulation of knowledge made by scientists through the ages. Relates modern scientific knowledge gained by space research to the overall field of scientific endeavor and gives examples of information received from orbiting spacecraft.

MAN'S REACH SHOULD EXCEED HIS GRASP
KSC No. 533 Sound, Color, 24 Minutes, 1972

The story of flight and of man's reach for a new freedom through aviation and the exploration of space. From the Wright Brothers flight at Kitty Hawk to the landing on the Moon and future missions to the planets, the film depicts the fulfilment of man's ancient dream of flight. Through the use of multiple images, the creative role of research is emphasized. Voices of scientists and statements by authors, poets, and philosophers, document man's search for knowledge.

BLUE PLANET
KSC No. 544 Sound, Color, 11 Minutes, 1972

"Wondering is the first step toward knowing." Against a background of Apollo launches and Moon landings, future manned space programs are discussed in light of their benefit to mankind.

MEANWHILE, BACK ON EARTH
KSC No. 551 Sound, Color, 13:30 Minutes, 1972

The film reviews the uses of a NASA-developed computer program (NASTRAN) for solving structural engineering design problems in industry. Illustrated is the impact on the design of automobile suspension, coliseum domes, electronic power plants, paper pulpmaking, railbeds and skyscrapers. Suitable for use with general science, math and physics topics and for special interest groups.

NEW VIEW OF SPACE
KSC No. 552 Sound, Color, 28 Minutes, 1973

A visually dynamic overview of the space program, past, present and future using the underlying theme of photography to tell the story. A visual experience compiled from a selection of over nine million feet of film in the NASA Film Depository.

EXPLORER TO SHUTTLE
KSC No. 563 Sound, Color, 27 Minutes, 1976

Vividly portrayed in this film is the development of the U. S. space program from its first successful satellite launch through the Skylab missions. Shows many historic launches and the construction of Launch Complex 39 where Apollo, Skylab and Apollo Soyuz Test Project missions were launched. Apollo lunar exploration activities and the Skylab experiments in Earth orbit are shown. Film ends by outlining future Space Shuttle operations. Suitable for use with space science, general science, physics and history topics and for the general public.

SPACE IN THE 70'S: CHALLENGE AND PROMISE
KSC No. 566 Sound, Color, 28 Minutes, 1973

This is a uniquely interesting film which combines a dramatic overview of the history and genius of our efforts to explore space with a detailed account of the activities and purposes of space missions. Much emphasis is placed on the benefits of space exploration which show future promise for enabling us to better cope with our environment and live much abundantly. Mariner, Skylab, Viking and Space Shuttle missions are among those discussed. This film is appropriate for use with general science, space science and Earth resources topics and for special interest groups and the general public.

SPACE EXPECTATIONS
KSC No. 571 Sound, Color, 26:30 Minutes, 1973

A look at varied viewpoints of America's space program from a cross section of the general public. Various cities throughout the U.S. were chosen to get reactions from the man-on-the-street, typical families, high school and college groups and young people who were born on the dates of John Glenn's flight and the first lunar landing. The result is an interesting, unrehearsed series of reactions in response to our space efforts.

APOLLO/SOYUZ TEST PROJECT
KSC No. 572 Sound, Color, 12 Minutes, 1973

The Apollo/Soyuz Project was the link-up of the first joint U.S. and U.S.S.R. spacecraft in space, which took place in 1975. The film includes animated sequences of the mission and the basic purpose and philosophy of international cooperation in space.

SMALL STEPS – GIANT STRIDES
KSC No. 573 Sound, Color, 28:30 Minutes, 1973

The film was produced to honor the 15th Anniversary of the National Aeronautics and Space Administration, 1958-1973. It visually portrays the historic accomplishments during the period and how we have benefitted from the new technology developed. Narrated by Isaac Asimov.

PARTNERSHIP INTO SPACE
KSC No. 601 Sound, Color, 27 Minutes, 1975

An excellent documentary which describes the joint efforts of the United States and Germany on Project Helios, a mission to further explore the Sun. This film presents a brief history of the role of the Sun in our early religious beliefs and effects of the activities of the Sun on our environment. The purpose of the mission and mission preparations from planning to launch are expertly illustrated. In this film our efforts to improve our ability to predict changes in our environment are highlighted. It is appropriate for use with space science, Earth resources, astronomy and general science topics and for special interest groups and general information.

LIFE BEYOND EARTH – THE MIND OF MAN
KSC No. 605 Sound, Color, 25 Minutes, 1975

This film presents excerpts from a symposium on the possibility of other intelligent forms of life in the universe and how modern scientists think that our present beliefs and attitudes might be changed if contact with an extraterrestrial life is ever established. The film contains interesting new opinions advanced by noted scientists in chemistry, physics, astronomy and other fields. The views of a theologian are also expressed on this subject as related to modern theology. This is a film which arouses controversy and discussion. It might be appropriate for use with astronomy, biology and public information topics as well as for special interest groups.

FLORIDA SPACE COAST: PROFILE OF PROGRESS
KSC No. 609 Sound, Color, 28 Minutes, 1975

This film examines the impact of NASA's Kennedy Space Center on the Brevard County, Florida, area. The stimulation of the local economy is expertly illustrated by the expanding population, the boom in con-

struction, the expansion of educational facilities and the growth and diversification of recreational opportunities. This film is most appropriate for use with state history, space awareness, population, ecology and community planning topics and for general public information.

THE MISSION OF APOLLO/SOYUZ
KSC No. 610 Sound, Color, 28:30 Minutes, 1975

An informative documentary designed to acquaint the public with the Apollo/Soyuz mission and its purpose. Mission preparation, launch, joint inflight activities, and recovery of both spacecraft are dramatically presented. The spirit of cooperation between the United States and Russian scientific communities is uniquely captured in this film . This presentation might be appropriate for use with space science, current history, general science and space awareness topics and for special interest groups.

FIELD TRIP TO SPACE FRONTIERS
KSC No. 619 Sound, Color, 8 Minutes, 1976

The film serves as a guide and preview on what to expect from a field trip to the Kennedy Space Center. The theme of the film is the sharing of information as an educational experience. A youthful group is followed through an aerospace frontier space trip. Information is shared on some suggested procedures to follow for the trip; various elements of the field trip are shown, and sample activities are explored within the time frame to be spent by the group at the Kennedy Space Center. Exhibits, lecture-demonstrations, films, bus tour, eating facilities and souvenir availability are highlighted. The film is a valuable tool for use when making preparations for a group field trip to the Kennedy Space Center and/or as a review after such a trip.

THINK ZERO G
KSC No. 622 Color, Sound, 15:30 Minutes, 1976

The need to always consider the effect of weightlessness on persons and materials to be sent into space is outlined in some detail in this film. Shown are experiments in jet aircraft, space flight simulators and the huge neutral buoyancy tank at the Marshall Space Flight Center in Alabama. Some of the planning for Space Shuttle operations is illustrated. Suitable for use with general science and physics topics and for special interest groups.

FLYING MACHINES
KSC No. 646 Sound, Color, 27:30 Minutes, 1978

Man's love affair with flying, from Kitty Hawk to the Space Shuttle. Discusses planned improvements for aircraft of the future, including winglets, supercritical wing technology, stall/spin research and suppression of airframe/engine noise. Also mentions importance of human factor in research and development. Narrated by Cliff Robertson, this dramatic presentation shows some of the most advanced aircraft being flown by NASA, including the triple-sonic YF-12 and F-8 Digital Fly-By-Wire aircraft, and the computer research involved in their development.

WHERE DREAMS COME TRUE
KSC No. 654, Sound, Color, 26 Minutes, 1979

Highlights the increasing numbers of minorities and women employed by NASA. Astronauts, engineers, technicians and others explain, in personal interviews, how they became interested in their particular fields and what they are doing to help the nation's space program. Narrated by actor Ricardo Montalban. Good for use as a recruitment film.

SPACEPORT SANCTUARY
KSC No. 655, Sound, Color, 15 Minutes, 1979

Shows how wildlife and technology co-exist at the NASA Kennedy Space Center. Contains footage of many endangered and threatened species of birds and animals which inhabit the Merritt Island National Wildlife Refuge around the spaceport.

SHUTTLE INTO SPACE*
KSC No. 657, Sound, Color, 14:30 Minutes, 1979

A true part of our environment, space can be widely used if it can be reached. This film follows the history of man's efforts to produce suitable spacecraft, beginning with the Chinese and their gunpowder. It includes Robert Goddard's embryonic rockets of the 1920's, and the modern day rockets which powered man to the moon. First of a series of seven films developed by the Marshall Space Flight Center, It can stand on its own as an overview of spaceflight history. Lesson Guide - Appendix A.

SPACE FOR WOMEN
KSC No. 669 Sound, Color, 28 Minutes, 1981

This film outlines the opportunities available for women in NASA. The film interviews several women on the job and discusses how their career interests parallel the needs of the space agency. Women now hold jobs as astronaut mission specialist, behavioral specialist, aeronautical engineer, electrical engineer, satellite imagery research scientist, computer engineer, and public information specialist.

SPACE RESEARCH AND YOU. . . YOUR HOME AND ENVIRONMENT
KSC No. 672 Sound, Color, 15 Minutes, 1981

The film illustrates some ways in which spacecraft sent to other planets have provided new insights into the complex processes that formed and continue to modify the Earth. Study of the Earth has been furthered by orbiting satellites such as the Landsat, which can detect pollution, monitor crop growth, search for new minerals and energy resources, and record surface changes. Improving other energy saving devices, such as solar cells and wind turbines, is explored.

SPACE RESEARCH AND YOU . . . YOUR TRANSPORTATION
KSC No. 673 Sound, Color, 15 Minutes, 1981

This film examines how NASA research has led to improvements in land, sea, and air travel. New technology for greater safety, speed, and energy efficiency are explored. Alternatives to the internal combustion engine are demonstrated. A new vertical takeoff and landing plane that combines the convenience of a helicopter with the speed and efficiency of a conventional airplane is shown. New wingtip designs, a result of NASA aeronautical research, are shown incorporated into business jets, as well as new lightweight materials for jet aircraft manufacturing.

SPACE RESEARCH AND YOU. . . YOUR HEALTH
KSC No. 674 Sound, Color, 15 Minutes, 1981

This film depicts a variety of medical advances made possible because of technology developed for the space program. From components miniaturized for spacecraft comes a programmable pacemaker for heart patients. A Programmable Implantable Medication System (PIMS) monitors the sugar level in the blood of a diabetic patient and dispenses medication from a reservior within the device. Camera systems from the Viking lander spacecraft have been adapted into optical devices that assist in corrective surgery and in diagnosing heart disease, especially blockage in arteries. Satellites allow a patient to be examined by a specialist thousands of miles away.

1982 SPACEPORT OPERATIONS
KSC No. 678 Sound, Color, 22:40 Minutes, 1983

Shows the third, fourth, and fifth flights of the Space Shuttle, including extensive in-flight coverage of the STS-3 and STS-5, the latter being the first operational mission.

Explains how the STS-3 flight was primarily a "heat test" of the orbiter, turning it several ways to expose all areas to intense sunlight. On STS-5, shows the first two commercial spacecraft being released into orbit. The second orbiter, Challenger, arrives at KSC and its main engines are fired on the pad for 20 seconds. The Spacelab scientific mission planned for 1983 is covered, as are five Delta launches and two Atlas-Centaurs, six carrying commercial communications spacecraft and one Delta carrying a Landsat (launched from Vandenberg). A busy year at the nation's spaceport.

NASA FACILITIES

THE BIG CHALLENGE
KSC No. 378 Sound, Color, 28 Minutes, 1967

The film opens with the historic statement of the late President John F. Kennedy announcing the national goal of landing men on the Moon in this decade. Following a study group's selection of Merritt Island as

the location for America's Spaceport, the Corps of Engineers is introduced as the agency responsible for design and construction supervision. The requirements which indicate design and size of facilities are outlined and the viewer is shown unique highlights of construction in a logical sequence paralleling operational use of the facilities. The Earth-orbiting vehicle, Saturn IB lifts off at the close as the viewer begins to appreciate that this nation is effectively meeting "The Big Challenge."

MERCURY PROGRAM

FREEDOM 7
KSC No. 19 Sound, Color, 28 Minutes, 1961

Completes the story of Astronaut Alan B. Shepard's flight in Freedom 7. Film shows pre-launch preparations, suiting-up of Shepard, launch, on-board film (Shepard in spacecraft during flight), Earth and sky scenes as taken from the spacecraft and recovery.

FRIENDSHIP 7
KSC No. 51 Sound, Color, 58 Minutes, 1962

John Glenn waited three years to cross the threshold of space and orbit the Earth. Tracking stations are ready as all the world awaits the flight of Friendship 7. The spacecraft is launched and inserted into orbit. America's first orbiting astronaut circles the Earth every eighty-eight minutes. His observations and reactions are shown while the rhythmic beat of his heart is heard in the background. Signs of impending disaster are relayed to John Glenn with recommendations for reentry. Friendship 7 encounters the searing heat of the atmosphere, which Glenn describes as "a real fireball outside." This dramatic account ends with his recovery and congratulations aboard ship.

FLIGHT OF FAITH 7
KSC No. 132 Sound, Color, 28:30 Minutes, 1963

L. Gordon Cooper's background as a test pilot and his extensive training as an astronaut are reviewed. The launch and flight of Faith 7 are shown through the use of animation, including separation of launch vehicle and spacecraft and the path of the spacecraft. Various experiments that took place during the flight are explained. Reentry and recovery are covered from the time the parachute opens until Cooper leaves his spacecraft aboard the carrier.

REACH FOR SPACE
KSC No. 230 Sound, Color, 33 Minutes, 1962

This is a film record of all launchings in the Mercury Program in which a production spacecraft was used. This film explains test objectives of each launching and evaluates the results which were obtained.

THE WORLD WAS THERE
KSC No. 603 Sound, Color, 27:30 Minutes, 1975 (Re-release)

The story of how a free press functions in our society to keep the public constantly informed. The film uses the Mercury manned space missions to demonstrate how the mass media pool their resources to bring the World to the scene of significant events. This film is appropriate for use with journalism, social studies and public information topics and for special interest groups.

GEMINI PROGRAM

THE FOUR DAYS OF GEMINI 4
KSC No. 228 Sound, Color, 28 Minutes, 1965

A documentary film covering the spectacular Gemini-Titan 4 mission of Astronauts James A. McDivitt and Edward White. Includes a color sequence of prelaunch and launch activities, astronaut White's spectacular space-walk, and other experiments conducted on the four-day mission. Included in the description of the experiments are photographs of the Earth, using both narration and actual voice communications of the astronauts inside the spacecraft. The film also depicts the preflight training of McDivitt and White and takes a detailed look at White's Extra Vehicular Activity suit and space-gun.

COUNTDOWN TO RENDEZVOUS
KSC No. 312 Sound, Color, 13:30 Minutes, 1966

This film shows the complexities of the planning, coordination and work necessary for launching two manned space vehicles from the same pad within eight days of each other. It shows the specific steps, systems checks and tests, and the suiting up of the astronauts. Excellent views of the liftoffs, as well as a closeup of the two spacecraft within a few feet of each other.

LEGACY OF GEMINI
KSC No. 395 Sound, Color, 28 Minutes, 1967

This film shows the major accomplishments of Gemini rendezvous, docking, long duration flight, walking in space, photography of the Earth from orbit and controlled reentry in broad and nontechnical fashion, pointing up their importance to the U.S. space effort in general, and to the Apollo program in particular.

APOLLO PROGRAM

APOLLO 4 MISSION
KSC No. 428 Sound, Color, 16 Minutes, 1968

Shows the launch of the Apollo 4 which reached an altitude of 11,232 miles. As Apollo 4 climbed toward this peak altitude, a camera pointed out the spacecraft window recorded views of Earth. The Service Module propelled the Command Module into reentry velocity of approximately 25,000 miles per hour. The successful mission was completed some 8½ hours after launch.

FLIGHT OF APOLLO 7
KSC No. 440 Sound, Color, 14 Minutes, 1968

Report on the first manned Apollo mission. Major events include the launch, a transposition and docking maneuver, a rendezvous maneuver, TV transmissions from spacecraft, reentry and recovery. The film also deals with the life and work aboard the Command Module during the eleven-day mission. Excellent motion picture footage of crew activities in space.

DEBRIEF: APOLLO 8
KSC No. 445 Sound, Color, 28 Minutes, 1969

A documentary film on the successful flight of Apollo 8. The film includes spectacular photography of the Moon and Earth taken by the three Apollo astronauts as well as assessments of the flight by prominent national figures. The film not only tells the story of the lunar orbit mission, but also sets the stage for future flights in the Apollo series.

APOLLO 9: THE SPACE DUET OF SPIDER AND GUMDROP
KSC No. 457 Sound, Color, 28 Minutes, 1969

A pictorial documentary of the Apollo 9 mission, showing Earth orbital rendezvous and docking of the Command Module (Gumdrop) and the Lunar Module (Spider). An introspective view of Astronauts McDivitt, Scott and Schweickart before, during and after their Apollo 9 flight. With minimal narration and special music, the film follows the astronauts through training activities, press interviews, launch preparation, orbital maneuvers, and recovery.

APOLLO 10: GREEN LIGHT FOR A LUNAR LANDING
KSC No. 486 Sound, Color, 28:30 Minutes, 1969

With spectacular views of the Earth, the Moon and onboard activities by the astronauts, this film features dramatic highlights of the Apollo 10 mission which took men within nine miles of the lunar surface and paved the way to a manned lunar landing. The viewer is given a close-up look at the Moon as the Lunar Module approaches a future landing site. The film traces the Apollo 10 mission from launch preparations through complex lunar orbital maneuvers and successful return to Earth, and shows the Apollo 11 crew training for man's first landing on the Moon.

APOLLO 11 LAUNCH MISSION REPORT
KSC No. 491 Sound, Color, 27 Minutes, 1969

This film opens with the introduction of the Apollo 11 crew and its mission objective, "Land On The Moon And Return." The Apollo/

Saturn V space vehicle is briefly reviewed following by a montage of the successful space missions of Apollos 7, 8, 9 and 10. Launch day activities at Kennedy Space Center are covered and dramatic scenes of liftoff and tracking of the Apollo 11 are shown. Docking with the Lunar Module, separation of the Lunar Module from the Command Module, and the descent of the Lunar Module to the Moon's surface are shown. Black and white tracking transmissions from the lunar surface show man's first steps on the Moon, the gathering of lunar soil samples and other lunar surface activities. Color film is again used to show liftoff from the Moon and rendezvous with the orbiting Command Module. Scenes of splashdown in the Pacific Ocean, recovery of the crew and spacecraft and greetings of the astronauts follow. The film ends with a brief message from the former Associate Director for Manned Space Flight, NASA.

APOLLO 12: PINPOINT FOR SCIENCE
KSC No. 497 Sound, Color 28 Minutes, 1969

This film illustrates the highlights of the Apollo 12 mission, the second landing of a manned spacecraft on the Moon, November 19, 1969. Through commentary by Astronauts Conrad, Gordon and Bean during their flight, and selected motion and still pictures taken by the astronauts, the film provides an eyewitness review of their historic journey to a pinpoint landing on the Ocean of Storms. Primary emphasis is given to lunar exploration by the crew, including deployment of scientific equipment, retrieval of parts of a Surveyor spacecraft which landed on the Moon in 1967, collection of rock and soil samples and photography.

EAGLE HAS LANDED: THE FLIGHT OF APOLLO 11 (REVISED)
KSC No. 498 Sound, Color, 28:30 Minutes, 1969

This film tells the story of the historic first landing of men on the Moon and of their safe return to Earth. It documents the Apollo 11 mission from the launching of the Apollo/Saturn V vehicle on July 16, 1969, through the lunar landing on July 20, 1969, to the return of Astronauts Armstrong, Aldrin and Collins to the Lunar Receiving Laboratory on July 27, 1969. Principal emphasis is given to activities on the lunar surface. Film is intended to give viewers an eyewitness experience as participants in the Apollo 11 mission. Still photographs, television transmissions and motion picture scenes recreate the highlights of man's greatest journey. Key events during the mission are described.

APOLLO 13: "HOUSTON, WE'VE GOT A PROBLEM"
KSC No. 504 Sound, Color, 28 Minutes, 1970

The story of dramatic flight to return Apollo 13 astronauts safely to Earth after an explosion severely damaged their Service Module and caused a loss of power and oxygen in their Command Module. The film emphasizes the teamwork between Astronauts Lovell, Haise, and Swigert as they work with ground personnel to solve a series of critical problems, and the response of people around the world to the successful return of the crew. The film features on-board photography of the astronauts in the Lunar Module and the presentation of Medals of Freedom to the crew.

APOLLO 14: MISSION TO FRA MAURO
KSC No. 513 Sound, Color, 28 Minutes, 1971

A brief prologue narrated by mission Commander Alan Shepard reviews the major manned space flight accomplishments since his first trip into space in 1961. The body of the film opens with the preparations at the Kennedy Space Center for Apollo 14. This sequence includes brief scenes of spacecraft and launch vehicle checkout, astronaut training and participation in major tests, plus rollout of the Apollo 14 vehicle. Launch day activity is shown with impressive scenes of the thousands of visitors present, astronaut ingress, launch team footage and the liftoff of the space vehicle. The highlights of the lunar landing mission are shown through the use of still photos, motion picture footage, and video tapes. The lunar surface activities of the astronauts are discussed in general terms. An effort is made to convey the purpose and accomplishments of the Apollo 14 mission to the general public. The film concludes with the recovery of Apollo 14 in the South Pacific and the return of the crew to the Kennedy Space Center.

APOLLO 15: IN THE MOUNTAINS OF THE MOON
KSC No. 527 Sound, Color, 28 Minutes, 1971

This ambitious and successful lunar landing mission includes details of the three lunar surface scientific expeditions, the experiments in lunar orbit and the dramatic return to Earth.

APOLLO 16: NOTHING SO HIDDEN
KSC No. 541 Sound, Color, 28 Minutes, 1972

Shows the highlights of man's fifth and next to last lunar landing, captures the anxieties and lighter moments of the events of the mission. The emotions of the teams in Mission Control and the Science Support Room were photographed and recorded as they happened. It includes spectacular lunar photography.

APOLLO 16: DESTINATION DESCARTES
KSC No. 542 Sound, Color, 14:30 Minutes, 1972

Man's fifth journey to the surface of the Moon is reviewed from liftoff to splashdown. The visit of Astronauts John Young and Charles Duke to the Descartes Highlands includes scenes of Flag and North Ray Crater, Smokey Mountain, and the "Grand Prix" road test of the lunar roving vehicle.

APOLLO 17: ON THE SHOULDERS OF GIANTS
KSC No. 553 Sound, Color, 28 Minutes, 1973

A documentary review of the Apollo 17 journey to Taurus-Littrow, the final lunar landing mission in the Apollo Program. The film depicts the highlights of the mission and then relates it to work then being done for the Skylab Program, the Apollo/Soyuz Test Project and the Space Shuttle.

THE TIME OF THE APOLLO
KSC No. 599 Sound, Color, 29 Minutes, 1975

An exceptionally well-prepared historical review of the Apollo Program. The film, which begins with the Apollo 8 astronauts reading the scriptures on their mission, illustrates the achievements of Apollo 8 as man's dreams are translated into reality. Apollo missions 9, 11, 12, 13 and 17 are also reviewed. The high quality information and photography result in a presentation of great educational value. This high-interest film might be appropriate for use with recent history, general science and public information topics and for special interest groups and career planning. It is a high-motivation presentation.

READING THE MOON'S SECRETS*
KSC No. 631 Sound, Color, 16 Minutes, 1976

This film has ten sections, each of which is followed by a question for students to answer. Film starts with a brief introduction about the six trips man has taken to the Moon and directions for viewing the film. The sections are: Traveling to the Moon, Life on the Moon, the Time Scale, Surface Features of the Moon, Lunar Rocks, Composition of the Moon, the Interior Structure of the Moon, Weathering and Erosion of the Lunar Surface, the Moon's Past and Its Future, and Secrets for Study in the Future. Lesson guide – Appendix A.

APOLLO DIGEST SERIES

REHEARSAL FOR THE MOON
KSC No. 461 Sound, Color, 7:10 Minutes, 1969

A report on the highly complex simulators used to train astronauts for the Apollo mission. Included are simulators which approximate the conditions to be encountered during flight to the Moon and the landing. Also shown are astronauts undergoing weightless simulation in an airplane and in water.

LAUNCH OF THE SATURN V
KSC No. 468 Sound, Color, 3:40 Minutes, 1969

A typical launch of the Saturn V is shown in an impressionistic manner against a background of contemporary music and without narration. The Saturn is shown being assembled, rolled to the launch pad and launched. The film closes after separation of the first stage and includes spectacular footage of the separation, taken from a camera mounted inside the second stage.

CANAVERAL TO KENNEDY
KSC No. 469 Sound, Color, 7:30 Minutes, 1969

A pictorial history of the Cape Canaveral/Cape Kennedy Space launch area from the first firing in 1950 until 1969. Primitive launch facilities

such as sandbagged shacks are contrasted with the complex area of NASA's Kennedy Space Center.

LIVING IN SPACE
KSC No. 477 Sound, Color, 8 Minutes, 1969

A report on the problems and solutions of astronauts taking oxygen, water and food into space with them. Also includes astronaut adjustments to weightlessness. The film answers the question: "How will the Apollo astronauts carry on their daily routine in space?"

SPACE SUIT
KSC No. 478 Sound, Color, 5 Minutes, 1969

A detailed story on the space suit worn by Apollo astronauts on trips to the Moon. Also included is footage of the extra-protection garment worn by astronauts who walk on the surface of the Moon.

ASTRONAUT TRAINING
KSC No. 481 Sound, Color, 7:30 Minutes, 1969

Apollo astronauts are shown preparing for flight during various training programs; in the classroom, in observatories, on geological surveys, underwater and in various simulators.

UNMANNED LUNAR MISSIONS

ASSIGNMENT: SHOOT THE MOON
KSC No. 409 Sound, Color, 28 Minutes, 1967

A dramatic portrait of the Moon as seen by Lunar Orbiter, Ranger and Surveyor spacecraft. A summary of what man learned about the Moon and how this knowledge aided manned lunar landings. The viewer travels across the surface of the Moon to examine in detail the major craters, the lunar soil, the back side of the Moon and other significant features.

SKYLAB PROGRAM

SKYLAB
KSC No. 534 Sound, Color, 27 Minutes, 1972

NASA launched its first manned space laboratory – Skylab – in 1973. The film shows the major objectives of the mission, its principal components and features, the four launches involved, and a few of the scientific investigations performed which illustrate their type of scope. The film concludes with Skylab's contribution to education, which included student proposals for activities and experiments carried out by astronauts.

YOUTH ACCEPTS THE SPACE CHALLENGE
KSC No. 567 Sound, Color, 28 Minutes, 1973

This film, which should be of particular interest to high school science students, tells of the involvement of approximately 4,000 high school students and their teachers in proposing science experiments for the Skylab Program. Demonstrates through simulation some of the 25 top proposals selected. Included in the experiments demonstrated are: "In Vitro Immunology," "Spider Web Formation," "Plant Growth and Phototropism," "Capillary Study," "Mass Measurement," "Neutron Analysis," and "Liquid Motion in Zero G." Suitable for use with general science, space science, biology, botany or chemistry topics and for the general public.

SKYLAB – AMERICA'S FIRST SPACE STATION
KSC No. 575 Sound, Color, 60 Minutes, 1975

A review of the activities of the three Skylab crews from initial launch through the end of the mission. Shows onboard problems and how they were solved, Extra Vehicular Activities, physiological and medical experiments, gathering data on the Sun and the Comet Kohoutek, study of Earth resources and the crews' adaption to the space environment.

FOUR ROOMS – EARTH VIEW
KSC No. 600 Sound, Color, 27 Minutes, 1975

This is an excellent film which tells the story of the three manned missions of Skylab. It describes the missions as a transition from space exploration to space exploitation. It proposes the possibility of future homes in orbit with the Earth as a window view. The launch, equipment malfunction, the various experiments and their benefits to man are presented in such a manner as to provide a high interest film segment far superior to many of the other films on this topic. This film is appropriate as general information for the general public and may be used with Earth resources, general science and space science topics.

SKYLAB SCIENCE

SCIENCE IN ORBIT
KSC No. 569 Sound, Color, 22 Minutes, 1973

Explains each of the major elements of the Skylab space station and focuses on 10 mission experiments.

MAGNETIC EFFECTS IN SPACE*
KSC No. 577 Sound, Color, 14 Minutes, 1975

This film, designed specifically for classroom use, introduces students and teachers to the weightless living aboard Skylab. They observe the characteristics of small bar magnets in the weightless environment and the effects of the Earth's magnetic field on them. Dr. Owen Garriott, science pilot of the second Skylab crew, shows and explains the tendency of the magnets to line up with the Earth's magnetic field. Opportunities for student participation are provided at specific points during the demonstration. Lesson guide – Appendix A.

CONSERVATION LAWS IN ZERO-G*
KSC No. 589 Sound, Color, 18 Minutes, 1974

This film helps students grasp the idea of angular momentum conservation. It shows and discusses a large number of examples, mostly from the zero-g environment of the orbiting Skylab space station. Illustrations in space are related to more familiar examples on Earth. The film shows how the spinning motion of a satellite changes to tumbling by dissipation of rotation energy while angular momentum is conserved. The level is most suitable to advanced high school or beginning undergraduate physics students. Lesson guide – Appendix A.

ZERO G*
KSC No. 591 Sound, Color, 15 Minutes, 1975

A brief synopsis of experiments performed in the weightless environment of Skylab. It explains the mechanics of weightlessness in terms of the absence of support and free fall. The film is appropriate for topics which include general science, physics and space awareness. Lesson guide – Appendix A.

GYROSCOPES IN SPACE*
KSC No. 592 Sound, Color, 16:30 Minutes, 1975

This film analyzes the mechanics involved in the action of gyroscopes in the Skylab environment of zero gravity. The phenomenon of precession is demonstrated using both a gyroscope and a magnet attached to a spinning disk. The film is appropriate for such topics as general science, physics and astronomy. Lesson guide – Appendix A.

FLUIDS IN WEIGHTLESSNESS*
KSC No. 607 Sound, Color, 15 Minutes, 1975

Dr. Owen Garriott, Skylab 3 astronaut, discusses the behavior of fluids in space. Several experiments are carried out to illustrate how surface forces dominate the behavior of water droplets in a weightless environment. The results of these experiments are used to explain nuclear fission, nuclear fusion, crystal growth and a theoretical model for the formation of galaxies and solar systems. This film might be appropriate for use with such topics as space science, advanced physical science, physics and hydraulics. Lesson guide – Appendix A.

MAGNETISM IN SPACE
KSC No. 608 Sound, Color, 19:30 Minutes, 1975

Dr. Owen Garriott discusses the Skylab experiments which were conducted to determine the effects of magnetism at zero gravity. During the several illustrations, Dr. Garriott shows how the strength of the Earth's magnetic field is calculated. Bar magnets and magnetic pendulums are used to determine effects of the Earth's magnetic field. The film shows how magnets are used in complex machines such as cars, motors and the Space Shuttle. This film might be appropriate for use with such topics as general and space science.

OPPORTUNITIES IN ZERO GRAVITY
KSC No. 616 Sound, Color, 18:30 Minutes, 1975

Skylab astronauts and medical personnel talk about and demonstrate experiments in zero gravity conditions. Included are major medical experiments and science investigations conducted during the three Skylab manned missions. Film concludes with an overview of Space Shuttle operations, including laboratory activities aboard the Spacelab to be carried aboard the Shuttle. Appropriate for use with general science, space science and physics topics and for special interest groups and the general public.

SPACE SHUTTLE

SPACELAB
KSC No. 588 Sound, Color, 9:30 Minutes, 1975

In this film, the European Space Agency presents a description of its plans to place a scientific laboratory in orbit using the United States Space Shuttle system. The film discusses the assembly process, instrumentation, life support systems and experiments in Earth resources, astronomy and biology. This presentation might be appropriate for general science, Earth resources and space awareness topics and for special interest groups.

THE AGE OF SPACE TRANSPORTATION
KSC No. 621 Sound, Color, 20 Minutes, 1976

The theme of this film is the impact the Space Shuttle will have on our lives. There are excellent views taken during previous manned space missions and there is lively music throughout the film. Various Shuttle payloads, including the Spacelab being developed and built by the European Space Agency, are discussed and illustrated. This film is appropriate for use with general science, space awareness and public information topics and for the general public.

SPACE SHUTTLE – TRANSPORT FOR TOMORROW
KSC No. 632 Sound, Color, 10 Minutes, 1977

In this brief overview of the Space Shuttle Program, the rollout of the first orbiter produced, designated Enterprise, is shown. Then through animation, the profile of a Shuttle mission is depicted from liftoff to landing. A quick review of the various types of payloads the Shuttle will carry to and from Earth orbit is featured. Appropriate for general science, physics and astronomy topics and for the general public.

SPACE SHUTTLE
KSC No. 633 Sound, Color, 14:30 Minutes, 1977

This film is slightly more technical than KSC No. 632. An animated description of Space Shuttle missions is provided. Also in the film is general information about the Shuttle and one of its payloads, the Spacelab produced by the European Space Agency. The roles of the NASA Centers and the companies involved with building the Shuttle are outlined. Tests of the orbiter when attached to a jumbo jetliner are described. Suitable for science, physics and astronomy topics and for the general public.

SPACELAB – LABORATORY OF TOMORROW
KSC No. 634 Sound, Color, 15 Minutes, 1977

This film moves rapidly from scenes of early manned launches to an animated profile of a Space Shuttle mission. Most of the footage is devoted to describing the reusable Spacelab, one of the major payloads of the Shuttle. Shown are different configurations of Spacelab and how they may be used for a variety of missions. Experiments which will be conducted aboard Spacelab are covered in the latter portion of the film. Suitable for general science, astronomy, physics and space awareness topics and for the general public.

GO FOR SEP
KSC No. 645 Sound, Color, 21 Minutes, 1978

Presents an overview of the complex series of Approach and Landing Tests of the Space Shuttle orbiter. Critical free flights 1 and 4 are experienced through the voices of the crew as they were recorded during descent and landing. Includes dramatic footage of preparations prior to the flights, in which the Orbiter "Enterprise" was launched from atop a specially-mounted 747 aircraft, to check out the aerodynamic characteristics of the orbiter prior to space flight.

ROUND TRIP INTO SPACE
KSC No. 651 Sound, Color, 13:25 Minutes, 1979

Discusses individual elements making up Space Transportation System—orbiter, external tank and solid rocket boosters. Shows testing required on all systems before Shuttle can be launched. Also details typical Space Shuttle flight from cargo loading to launch, orbital insertion, reentry and landing. Mentions possible payloads and future uses of Shuttle.

EXTENDING MAN'S WINGS
KSC No. 653 Sound, Color, 18 Minutes, 1979

Assembly and pre-flight checkout of the Space Shuttle is depicted through animation and actual footage of Orbiters Enterprise and Columbia. Discusses Shuttle's mission in space, including payload operations such as Spacelab. Concludes with Shuttle reentry and preparation for next orbital mission.

SPACE SHUTTLE: OVERVIEW
KSC No. 656 Sound, Color, 21 Minutes, 1980

In a detailed overview of the first Space Shuttle, this May, 1980 report delineates the Shuttle's components and its present stage of production. The contractors and their individual responsibilities and contributions are discussed as well as the problems encountered in completing the Shuttle. These latter have been chiefly, the Thermal Protection System (tiles) and the vibrations caused by the tremendous pressures required. However, emphasis is placed on the real value of the future Shuttle flights. These include the need to reduce high costs by having a reusable system, to increase productivity, and to expand capabilities in space. All of these are vital to business, science and defense. This film provides an excellent overview of the Shuttle and is suitable for college students and adults.

MILES OF TILES
KSC No. 665 Sound, Color, 28 Minutes, 1981

This film describes in detail the unique Thermal Protection System which protects the Space Shuttle during its searing reentry into Earth's atmosphere. Over 30,000 of these tiles, which are made of a silica fiber compound, are precisely milled and shaped, minutely inspected for possible cracks, and stored in protective units. Computer printouts identify the exact location where each tile must be placed. Slightly different kinds of tiles are installed on different sections of the orbiter, since they are subjected to varying intensities of temperature. Despite painstaking cementing, curing and reinforcing of the tiles, as well as numerous quality control procedures, many tiles had to be replaced on the first Orbiter, Columbia. Now an additional vacuum test is always performed on the tiles to ensure they will adhere firmly to the orbiter. Older students and adults will enjoy this fascinating chronicle.

SPACE SHUTTLE: MISSION TO FUTURE
KSC No. 667 Sound, Color, 28 Minutes, 1981

This film emphasizes the importance of the new door to space opened by the flight of the first Space Shuttle, Columbia. Writers James Michener and Isaac Asimov affirm that the goal of the Space Transportation System is to ensure global harmony while establishing a permanent relationship with space. Columbia is shown in various stages prior to launch. This includes the mating with its giant tank and solid rocket boosters in a building so huge it could have contained Robert Goddard's first rocket launch. Then Columbia is shown rolling out on its elephantine Crawler to its lonely vigil on the pad. Next follows a simu-

lation of Columbia's first mission into space and back and its impact on people all over the world. Finally, a graphic illustration of Columbia deftly switching from hypersonic to supersonic to typical aircraft speed is highlighted, followed by the Orbiter practicing landings in California. Columbia, and its sister ships, Challenger, Discovery, and Atlantis, will become the space fleet of the 1980's, the workhorses of the new age of space. This film provides an excellent overview of an amazing accomplishment.

STS-1 POST FLIGHT PRESS CONFERENCE
KSC No. 668 Sound, Color, 17 Minutes, 1981

This presentation features Astronauts John Young and Robert Crippen at their first Houston news briefing discussing their historic flight with a group of editors. The astronauts themselves narrate this film, which begins with their early morning breakfast, suit up, and trip to the launch pad. Film of engine ignition and liftoff is followed by solid rocket booster separation and external tank jettison. The astronauts described in detail what that first historic ride into orbit aboard the Space Shuttle was like. Also shown are the astronauts on-orbit activities as they describe their impressions of the earth below. The film concludes with reentry, the approach of the orbiter to the coast of California, and the landing of Columbia at the Dryden Flight Research Center.

SPACE SHUTTLE: REMARKABLE FLYING MACHINE
KSC No. 671 Sound, Color, 28 Minutes, 1981

This is a synopsis of the first flight of the Space Shuttle from launch at the Kennedy Space Center in Florida to landing at the Dryden Flight Research Center in California. Spectacular launch film is presented showing engine ignition, separation of the solid rocket boosters from the shuttle, and the jettisoning of the external tank just prior to orbit. Activities of Astronauts John Young and Robert Crippen while in space are shown, as well as on-orbit pictures of the earth below. Highlights are film taken from the orbiter during reentry and finally the landing of Columbia in California.

STS-5 MISSION REPORT
KSC No. 676 Sound, Color, 11 Minutes, 1983

First operational flight of the Space Shuttle, And the first four-man crew ever launched at once. The film covers the mission from launch preparations through liftoff and orbital deployment of two commercial communications satellites, the Anik C-3 Telesat for Canada and Satellite Business Systems—C for a United States firm. The smaller on-board experiments are shown and discussed. The landing at Edwards AFB in California is covered, as well as the flight back to KSC atop the 747 carrier aircraft.

OPENING NEW FRONTIERS
KSC No. 677 Sound, Color, 30 Minutes, 1983

The story of the first four Space Shuttle research and development flights, including footage on the development of the Space Shuttle Main Engines and the thermal protection system (the lightweight tiles) on the orbiter. It includes extensive coverage of the astronauts working in orbit, discusses the on-board experiments and the Payload Operations Control Center established at Houston to operate them, and lays the groundwork for the operational flights to follow.

STS-2 POST FLIGHT PRESS CONFERENCE
KSC No. 679 Sound, Color, 15 Minutes, 1982

Narrated by STS-2 astronauts Engle and Truly, this film consists primarily of in-flight coverage of the mission. It also contains coverage of the final astronaut preps, including boarding the vehicle, a look at the Florida coastline as STS-2 lifts off and climbs, and excellent film coverage of the solid rocket boosters being jettisoned and the external tank falling away later. Good views of the Earth below are shown as the Canadarm is operated. The landing at Edwards AFB is thoroughly covered.

STS-3 POST FLIGHT PRESS CONFERENCE
KSC No. 680 Sound, Color, 13 Minutes, 1982

This film, narrated by astronauts Lousma and Fullerton, shows them leaving the O&C Building for the launch pad, entering the orbiter, and the liftoff. Florida is seen falling away beneath, followed by the separation of the solid rocket boosters and the external tank. The payload bay doors are opened, and then the operation of the Canadarm is shown moving a diagnostic package around the orbiter environment with the Earth seen below. Extensive footage of the astronauts flying around the cabin as they eat, work, exercise, etc., is shown. This film contains some of the best Shuttle in-flight activities filmed to date. The landing at the Northrup Strip at White Sands, N. M., ends the mission.

STS-4 POST FLIGHT PRESS CONFERENCE
KSC No. 681 Sound, Color, 15 Minutes, 1982

Final test mission shows astronauts Mattingly and Hartsfield, wearing pressure suits for the last time, emerging from the O&C Building for the trip to the pad as the astronauts narrate their mission. The liftoff features good coverage of the two astronauts on the flight deck. In-orbit coverage shows the two astronauts working at their heavy experiment payload, including explaining and then operating the electrophoresis equipment. Film shows a spacesuit being donned (for inside tests only), and an astronaut exercising on a treadmill. Good coverage of the landing at Edwards AFB in California.

STS-5 POST FLIGHT PRESS CONFERENCE
KSC No. 682 Sound, Color, 15 Minutes, 1982

The first operational Space Shuttle mission features narration by the first four-man crew, Brand, Overmyer, Allen and Lenoir. The film opens with the liftoff and views of Florida below, followed by the separation of the solid rocket boosters. The descent of these boosters is captured by cameras on airplanes, showing the opening of the drogue and main parachutes, and the impact with the water. The payload of two commercial communications spacecraft are spun up and deployed from the cargo bay. The astronauts are shown preparing food and eating in weightlessness. Two astronauts don spacesuits but do not go outside. Rose-colored glow is seen through cabin windows during reentry as outside heats up. Good coverage of the landing at Edwards AFB in California.

STS-8 MISSION REPORT
KSC No. 683 Sound, Color, 13 Minutes, 1983

This film covers the first night launch of the Space Shuttle. It begins with the loading of the Insat 1B spacecraft and the astronauts preparing to board the orbiter. This film provides good footage of the flight deck as the Shuttle rises under the impulse of the solid rocket boosters, showing the shaking of the orbiter. The release of the spacecraft payload is filmed through the cabin windows. Communications tests are performed using the new Tracking and Data Relay Satellite, with excellent results. Dr. Thornton takes specimens and performs medical tests in orbit. The "red glow" previously reported on earlier missions is seen again through the cabin windows as the orbiter heats up during reentry. The landing at Edwards AFB in California is at night.

SPACE SHUTTLE – SPACELAB
KSC No. 684 Sound, Color, 12:30 Minutes, 1980

This film provides an overall view of the Spacelab which will be carried into orbit inside the Space Shuttle orbiter. It traces the Spacelab history, its basic design, the details of how it will work in space, etc. It also shows astronauts training on the ground for Spacelab missions, and footage of astronauts actually working in a predecessor scientific laboratory in orbit, Skylab. The film illustrates some planned Spacelab experiments, including production of medicines, composite materials, and crystals for electronic equipment. It also shows how, for the first time, principal scientists on the ground can work directly with the payload specialists operating the instruments in orbit.

SPACE SHUTTLE – GROUND SUPPORT
KSC No. 685 Sound, Color, 9 Minutes, 1980

This film provides an overall look at the roles of the NASA Kennedy, Johnson, Lewis, Goddard and Marshall Space Centers in supporting the Space Transportation System – the Space Shuttle. The roles of the Jet Propulsion Laboratory and Dryden Flight Research Facility are also described. It shows the work of each Center in the support area, and how all the different responsibilities mesh to form the complex support on the ground required to keep a Space Shuttle operating in orbit.

SPACE SHUTTLE – PROPULSION
KSC No. 686 Sound, Color, 11 Minutes, 1980

A detailed look at the solid rocket boosters, Space Shuttle main engines, and Orbital Maneuvering System engines that power the Space Shuttle. The extensive test program for the solids and main engines are shown, with many test firings. Simulations and actual firing of the small orbiter attitude thrusters can be seen.

SPACE SHUTTLE – EXTRA VEHICULAR ACTIVITY
KSC No. 687 Sound, Color, 9 Minutes, 1980

A history of extra vehicular activity from the first Gemini "Space walks" through the several outside activities during Skylab operations. The new, more flexible spacesuit designed for Space Shuttle astronauts is shown in detail, including the undergarment; how the suit works; and getting into it in orbit. The film includes some footage on how the astronauts train for such activities in "neutral bouyancy" simulators on the ground, in huge tanks filled with water. It also shows the new Manned Maneuvering Unit being used in training programs, and the "inflatable ball" that will be used to transport astronauts between ships during a rescue operation.

FULLY OPERATIONAL: STS 41-B MISSION
KSC No. 689 Sound, Color, 13 Minutes, 1984

This mission featured the launch of two communications satellites which failed to reach their proper orbits, but were later recovered and returned to Earth on the STS 51-A mission. It also shows the first untethered spacewalks, performed by astronauts McCandless and Stewart, first use of the Canadarm Remote Manipulator System with an astronaut riding on its end, and the first landing back at the Kennedy Space Center.

SHUTTLE FLOW AT THE KENNEDY SPACE CENTER
KSC No. 690 Sound, Color, 22 Minutes, 1984

The complicated work involved in processing the flight components of a Space Shuttle – the two solid rocket boosters, the external tank, and the orbiter – are shown at the Kennedy Space Center. This film also shows the many tasks required to process the payload, or cargo, following some items from their assembly and checkout buildings to the Vertical Processing Facility for integration with other payload componenets, and the installation in the orbiter at the Orbiter Processing Facility or at the pad. It includes Spacelab checkout scenes inside the largest spacecraft facility, the Operations & Checkout Building, and shows the huge Canister which transfers payloads being loaded and unloaded.

STS 41-C MISSION REPORT
KSC No. 691 Sound, Color, 13 Minutes, 1984

This was the first direct ascent into orbit for the Space Shuttle. The Long Duration Exposure Facility was deployed and left in orbit, to be recovered and returned to Earth after a year. The film shows extensive in-orbit footage of the first capture, repair and redeployment of a free-flying spacecraft, the Solar Maximum Mission satellite. This was the first operational use of the equipment tested on the 41-B mission.

STS 41-D MISSION REPORT
KSC No. 692 Sound, Color, 12 Minutes, 1984

This was the first launch of Orbiter Discovery, including test-firing the engines on the pad and the first abort of a Space Shuttle on the pad after orbiter engine ignition. It shows how the cargo for the planned next mission was then combined with that of 41-D; the release of three satellites in orbit; and in-orbit manufacturing by the first commercial payload specialist, engineer Charles Walker of McDonnell Douglas. The crew also performed a series of experiments, including erecting a solar sail over 100 ft high.

STS 41-C POST FLIGHT PRESS CONFERENCE
KSC No. 693 Sound, Color, 20 Minutes, 1984

At a post-launch press conference the astronaut crew shows photographs and provides narration of mission highlights. This film has somewhat more in-space coverage of the capture, repair and redeployment of the Solar Maximum Mission satellite than does KSC No. 691, of which it is a longer version.

STS-7 MISSION REPORT
KSC No. 694 Sound, Color, 12 Minutes, 1984

This mission features the deployment of two communications satellites for Canada and Indonesia. Among its "firsts" were: first flight by an American woman, astronaut Sally Ride; the first five-person flight crew ever launched on a single vehicle; first deployment and later retrieval, using the Remote Manipulator System Canadarm, of an independent orbiting spacecraft, the German SPAS-01; and first photographs of the orbiter taken from space (by the SPAS-01) with the Earth in the background below.

STS-9 MISSION REPORT
KSC No. 695 Sound Color, 10 Minutes, 1984

This was the first flight of a Spacelab, operated in orbit by four NASA astronauts and two non-NASA payload specialists, one each from the European Space Agency and the Massachusetts Institute of Technology. About 72 scientific investigations were carried out, half by weight contributed by ESA and half by NASA. The six-man crew divided into two crews working 12-hr shifts. These included studies of Space Adaptation Syndrome (space sickness), atmospheric and space plasma physics, atmospheric observations, and materials science and technology.

STS-6 MISSION REPORT
KSC No. 696 Sound, Color, 13 Minutes, 1984

This was the first flight of Orbiter Challenger, featuring the launch of the first Tracking and Data Relay Satellite (TDRS), the largest communications spacecraft ever flown. It also shows the first spacewalks in the Space Shuttle program, with two astronauts remaining tethered inside the cargo bay. It featured the first use of a lightweight external tank and lightweight solid rocket booster casings. The TDRS entered an unplanned low orbit, but was later moved up to the correct one under its own power.

STS 51-A POST FLIGHT PRESS CONFERENCE
KSC No. 697 Sound, Color, 19 Minutes, 1984

The astronaut crew provides narration and views of mission highlights, including excellent coverage of Gardner and Allen performing extravehicular activities in the process of recovering the PALAPA B-2 and WESTAR VI satellites.

U.S. SPACE STATION ASSEMBLY SCENARIO
KSC No. 698 Sound, Color, 12.5 Minutes, 1985

Using computer-generated graphics, this film outlines a scenario for assembling the Space Station in just seven flights. The old power-tower configuration is shown, but the techniques for assembly operations in space can also be used on the new dual keel plan.

STS 51-D POST FLIGHT PRESS CONFERENCE
KSC No. 699 Sound, Color, 25 Minutes, 1985

The astronauts narrate and show the deployment of the Anik C-1 and SYNCOM IV-3 (Leasat-3) spacecraft. The perigee motor on the latter failed to ignite. This film includes some excellent footage of making and installing two "flyswatter" devices on the end of the Canadarm, and using them to successfully engage the start-up switch on the SYNCOM IV-3. Also demonstrates physics in microgravity using toys, and shows a landing at KSC.

STS 51-F POST FLIGHT PRESS CONFERENCE
KSC No. 700 Sound, Color, 21 Minutes, 1985

The astronaut crew provides commentary on the first flight of a Spacelab with all instruments exposed to space on pallets. This film includes scenes of operating the new Instrument Pointing System, and extensive coverage of the astronauts at work in the orbiter as they operate the Spacelab instruments.

STS 51-I POST FLIGHT PRESS CONFERENCE
KSC No. 701 Sound, Color, 25.5 Minutes 1985

The astronaut crew shows coverage of this ambitious mission, where the AUSSAT 1, ASC 1, and SYNCOM IV-4 (Leasat 4) spacecraft were all launched, prior to rendezvousing with and repairing the ailing

SYNCOM IV-3 satellite. Excellent footage of the astronauts working in space during the successful recovery and repair operations.

STS 51-D AND 51-B COMBINED MISSION REPORT
KSC No. 702 Sound, Color, 17 Minutes, 1985

Discovery and then Challenger were launched within 17 days of each other. The first mission deployed the Anik C-1 and SYNCOM IV-3 (Leasat 3) spacecraft, and attempted to start the latter using "fly-swatters" attached to the Canadarm when its perigee motor failed to ignite. Physics in microgravity were demonstrated using toys. Senator Jake Garn (R-Utah) was aboard as a payload specialist. The 51-B crew photographed the east coast of the USA as they moved north along it after liftoff. They operated the instruments on the Spacelab 3 and obtained excellent photographs of auroral light.

STS 51-G LAUNCH MISSION REPORT
KSC No. 703 Sound, Color, 10 Minutes, 1985

This flight featured the participation of Arabian and French payload specialists Sultan Salman Al-Saud and Patrick Baudry. The crew deployed three communications satellites, Morelos-A for Mexico, Arabsat-A for the Arab League, and Telstar 3-D for AT&T. Spartan 1 was deployed and flew alongside Discovery under its own power, then was recovered. Baudry conducted several physiological experiments on himself and other crew members.

STS 51-B POST FLIGHT PRESS CONFERENCE
KSC No. 704 Sound, Color, 22 Minutes, 1985

The astronauts narrate highlights of a mission which starts with a flight parallel to the east coast of the United States, showing it in real time from Florida to Cape Cod. It features extensive coverage of the work inside Spacelab 3, including 'flying' through the connection tunnel. This crew deployed the NUSAT satellite from a small canister, demonstrated the wall-mounted sleeping bunks, and took excellent footage of the auroral lights.

STS 51-G POST FLIGHT PRESS CONFERENCE
KSC No. 705 Sound, Color, 26 Minutes, 1985

The astronaut crew narrates and shows highlights from a mission that includes the deployment of three communications satellites, Morelos-A for Mexico, Arabsat-A for the Arab League, and Telstar 3-D for AT&T. This flight crew included two foreign nationals, Arabian and French payload specialists Sultan Salman Al-Saud and Patrick Baudry. Spartan 1 was photographed being deployed, flying alongside Discovery under its own power, and being returned to the cargo bay by the Canadarm. Baudry conducted several physiological experiments on himself and other crew members.

STS 61-A MISSION REPORT
KSC No. 706 Sound, Color, 14 Minutes, 1985

This was the first 8-person crew, with two payload specialists from West Germany and one from the European Space Agency operating the equipment aboard Spacelab D-1, along with three mission specialist astronauts. About one-third of the operating time was devoted to materials science experiments in crystal growth and fluid physics phenomena. One unique result was a liquid droplet shaped into a square! West Germany sponsored this mission, and provided Spacelab ground control from its own facility in Oberpfaffenhofen.

STS 61-A POST FLIGHT PRESS CONFERENCE
KSC No. 707 Sound, Color, 26.5 Minutes, 1985

The astronaut crew narrates and shows the deployment of the GLOMAR satellite from a canister, and provides extensive coverage of the work performed inside Spacelab D-1. This includes good views of astronauts riding a floor-mounted sled in microgravity, floating drops of liquid changing shape when hit by jets of air, and grass seeds that sprout and grow in all directions.

STS 61-B POST FLIGHT PRESS CONFERENCE
KSC No. 708 Sound, Color, 21 Minutes, 1985

The crew shows and describes the deployment of the Morelos-B, AUSSAT-2 and RCA SATCOM Ku-2 satellites. This film features excellent coverage of astronauts in space erecting the EASE/ACCESS space construction structures, including building a tall truss that is then handled by the Canadarm. Two astronauts were outside the orbiter for periods of 5.5 hours one day and 6.5 hours the next day.

STS 61-C POST FLIGHT PRESS CONFERENCE
KSC No. 709 Sound, Color, 26 Minutes, 1986

This flight was unusual in that it was a night launch and night landing. Congressman Bill Nelson was a payload specialist. The crew shows the release of the RCA SATCOM Ku-1 satellite. There were 13 "Get-away Special" experiments in canisters in the cargo bay. Food preparation and eating in microgravity is shown in some detail.

STS 51-I MISSION REPORT
KSC No. 710 Sound, Color, 14 Minutes, 1985

This was an ambitious five-person mission, where the AUSSAT 1, ASC 1, and SYNCOM IV-4 (Leasat 4) communications spacecraft were all deployed successfully. The orbiter then rendezvoused with, captured, and repaired the ailing SYNCOM IV-3 satellite. It was returned to space, and later entered normal service. Excellent footage of the astronauts working in space during the recovery and repair operations, including manually handling the huge spacecraft.

ASTRONOMY

ORBITING SOLAR OBSERVATORY
KSC No. 93 Sound, Color, 28 Minutes, 1962

The physical properties of the Sun as well as its dangers and benefits are presented. This is an interesting and informative film which gives close-up views of an OSO and shows some of its functions. Also reveals information about other missions, such as Orbiting Geophysical Observatories.

UNIVERSE
KSC No. 102 Sound, Color, 26 Minutes, 1976

This is an updated version of the 1960 black and white film of the same title. By use of actual photographs, animation and artists' concepts, the major features of the universe and graphically presented. Film discusses our sun and its planets, galaxies, nebulae, quasars, red giants, supernovae, pulsars, black holes and the search for extraterrestrial life. Suitable for general science, astronomy, space awareness and public information topics and for the general public.

CELESTIAL MECHANICS AND THE LUNAR PROBE
KSC No. 121 Sound, Color, 12 Minutes, 1958

Describes, through animation, the orbits of the Earth and the Moon, the Earth's rotation, and how these factors must all be considered in guiding a spaceship on a lunar probe. A good instructional film for all ages.

THE CLOUDS OF VENUS
KSC No. 124 Sound, Color, 27 Minutes, 1963

Produced by Jet Propulsion Laboratory. This film documents the planning, launching and results of the space probe, Mariner II. Information relayed by Mariner II during its passage past the planet Venus on December 14, 1962, is included, as are some of the scientific conclusions deduced from this information.

VIEW OF THE SKY
KSC No. 414 Sound, Color, 27:40 Minutes, 1967

Colorful and unusual film techniques help tell the story of the evolution of man's view of the Universe. Observations and theories from the early beginnings to the space age are explored, with particular attention given to the views of Ptolemy, Copernicus, Galileo, Newton and Einstein. Film concludes with the historic Lunar Orbiter photographs of the Lunar surface.

RADIO ASTRONOMY EXPLORER
KSC No. 436 Sound, Color, 30 Minutes, 1968

Against the background of research currently performed by optical and ground-based radio astronomy, this film describes the design and function of the new Radio Astronomy Explorer, a spacecraft with 1,500-foot antennas which detect and relay various types of radio waves emitted by the Sun, Earth, and the planet Jupiter. Dr. John F. Clark,

Director of the NASA Goddard Space Flight Center, and Dr. John Findlay, Chairman of the U.S. Lunar and Planetary Missions Board, discuss the significance of this new satellite.

SEAS OF INFINITY
KSC No. 480 Sound, Color, 14:30 Minutes, 1969

Reviews the planning, development, launching and function of Orbiting Astronomical Observatories, which carry precision telescopes to study the solar system and distant stars. Features comments by leading scientists on the potential of this advancement in astronomy.

SEEDS OF DISCOVERY*
KSC No. 503 Sound, Color, 28 Minutes, 1970

Traces the evolution of man's concept of the solar system. Shows how we can expand our knowledge of the universe by putting instruments above the atmosphere. Presents the general features of the planets and specific data obtained from spacecraft flybys of Mars and Venus in the 1960's. Shows the various plans to send spacecraft to the planets during the 1970's and the plans to study our own atmosphere on a global basis. Forecasts the benefits that may be expected from expanding our knowledge of the Earth, the solar system and the universe. Narrated by James Franciscus. Lesson guide – Appendix A.

THE MOON – OLD AND NEW
KSC No. 512 Sound, Color, 25 Minutes, 1969

Illustrates briefly the history of lunar studies before the Apollo 11 mission. It then covers the major things we have learned and the major questions that have emerged from studying Apollo 11 and 12 lunar samples plus the data returned from scientific instruments left on the surface. It closes with a brief resumé of investigations that scientists would like to undertake in the future.

EXPLORATION OF THE PLANETS
KSC No. 526 Sound, Color, 25 Minutes, 1971

Is it true that sometimes more can be learned about a place from another place? Will studying the other planets in our solar system tell us more about the Earth than can be learned from Earth itself? This film answere in the affirmative as it tell about spacecraft flybys of Mercury and Venus, about Mars orbiters and landers, and about possible flybys of outer planets during a unique lineup of Jupiter, Saturn, Uranus and Neptune.

THE MOON – AN EMERGING PLANET
KSC No. 565 Sound, Color, 13 Minutes, 1973

The film reviews what we have learned of the early events in the history of the Moon in non-technical terms. It briefly compares the geology of the Moon with that of the Earth and other planets.

OUR SOLAR SYSTEM
KSC No. 583 Sound, Color, 4:30 Minutes, 1973

Teaches names, line-up and characteristics of the planets of our solar system. The film is done in animation and sung to a catchy tune, "My Very Educated Mother Just Served Us Nine Pizza-pies."

EARTH SUN RELATIONSHIP
KSC No. 584 Sound, Color, 6 Minutes, 1973

An animated motion picture depicting how our Sun and planets were formed. The film further explains how, through early space probes, we discovered the Van Allen Belt and how the Earth is protected from solar wind and ion particles by the magnetosphere. Finally, the film depicts how a sun dies.

JUPITER ODYSSEY
KSC No. 585 Sound, Color, 27 Minutes, 1975

This film presents a brief description of the planets of our solar system using information obtained from recent space exploration. The film emphasizes the flight of Pioneer 10, the mechanics of the spacecraft and the new information obtained from that mission to Jupiter and its 12 moons. This is a dramatic film illustrated with vivid color simulations and actual photography. It might be most appropriately used with topics on general science, space science and public information and for special interest groups.

HEAO: THE NEW UNIVERSE
KSC No. 620 Sound, Color, 20 Minutes, 1976

The views of four experts about the need for further study of highly energetic radiation from space are outlined in this film. Quasars, pulsars and black holes are discussed and illustrated. The mission of the three High Energy Astronomical Observatories scheduled for launch between 1977 and 1979 are outlined. This film has relevance to topics such as general science, physics and astronomy and for special interest groups.

MERCURY, EXPLORATION OF A PLANET
KSC No. 636 Sound, Color 23:30 Minutes, 1976

The flight of the Mariner 10 spacecraft to Venus and Mercury is detailed in animation and photography. Views of Mercury are featured. Includes animation on origin of the solar system. Jet Propulsion Laboratory Director Dr. Bruce C. Murray comments on mission.

THE CHANGING UNIVERSE*
KSC No. 661 Sound, Color, 14:30 MInutes, 1979

Although scientists have studied the stars for centuries, the satellites such as the High Energy Astronomy Observatories offer the first real opportunity to observe them from space. In order to understand the explosive nature of our universe, it is necessary to study our closest star, the Sun. This film depicts the fusion of hydrogen atoms into helium atoms, and the accompanying release of energy, as the source of the Sun's tremendous power. In addition to the core, the next three outer layers, namely, the photosphere, chromosphere, and corona, are discussed in detail. From the Sun's rotations, the magnetic field becomes stretched and twisted so that it ruptures the Sun's surface and inhibits the bubbling hot gases. This lower temperature causes less light to be emitted and results in what we call sunspots. Such phenomena, as well as X-rays and gamma radiation from deep space, can be more readily observed with the advent of satellites such as HEAO. Lesson Guide - Appendix A.

PICTURE THE SOLAR SYSTEM*
KSC No. 662 Sound, Color, 14:30 Minutes, 1979

This film is an excellent introduction to the current view of the solar system. Although Copernicus and Galileo's original depictions were quite accurate, the magnetic fields around planets, Earthlike winds on Mars, and Earthlike clouds on Venus, were never really known until the space age. Intriguing questions are raised as to the validity of the theory that the inner planets were formed from hot, solid material, while the outer, gaseous planets evolved from material dispersed by solar winds. Pioneer Venus demonstrated that the gas, argon, is more abundant on Venus than on Earth, thus conflicting with the theory. This film would be an appropriate starting point for introducing a class to the study of the solar system. Lesson Guide - Appendix A.

SPACE TELESCOPE: AN OBSERVATORY IN SPACE
KSC No. 666 Sound, Color, 15:40 Minutes, 1981

The invention of the telescope has aided Earthbound astronomers in viewing the heavens for over 300 years, far more precisely than the human eye can see. Newton's original design is still the prototype for giant telescopes such as those at Palomar and Kitt Peak. Now the 1980's will bring about a new, dynamic model, the Space Telescope, which will perceive celestial objects ten times more clearly and 50 times further than any Earth based instrument. This amazing device, with mirrors polished to one half a millionth of an inch, will be carried into space and placed in orbit 500 miles above Earth by the reusable Space Shuttle. The Shuttle will return periodically to refurbish and repair the telescope, extending its effectiveness by some 20 years. This fascinating film suggests that the Space Telescope, like Galileo's early model, may find extraordinary discoveries, everywhere it looks. Students from Junior High level as well as adults will find this film enlightening.

VOYAGER
KSC No. 688 Sound, Color, 28 Minutes, 1984

This film provides spectacular coverage of the exploration of Jupiter and Saturn by the two Voyager spacecraft. It includes photographs of the two planets, the Galilean satellites of Jupiter, and several of the moons of Saturn. The latter include Titan, the only moon known to have an atmosphere. The faint ring around Jupiter discovered by Voyager 1 is depicted, and the beautiful rings of Saturn are seen from

both sides. The eruption of sulfur volcanos on Io is shown. Artists images derived from the acquired data provide exciting and informative close-ups of the surfaces of several moons. The overall Voyager program, which has provided some of the most exciting and surprising information to date on our solar system, is covered in some detail.

COMMUNICATIONS

TELSTAR
KSC No. 284 Sound, Color, 26:30 Minutes, 1965

Documentary film on the communications satellite, Telstar. Worldwide space communications and television systems of the future are viewed. This film was produced by the Bell Telephone Comapny.

IF ONE TODAY – TWO TOMORROW
KSC No. 638 Sound, Color, 28 Minutes, 1976

Addresses the need for the worldwide use of communication technology for learning and growing as world population increases. The film takes you to India, Pakistan, El Salvador, Niger, Kenya, Thailand, Equador, Bolivia, Guatemala, Alaska and to remote Indian communities in the U.S. It graphically describes how radio, television, and communications satellite systems are used as instruments for education.

LIVE VIA SATELLITE*
KSC No. 658 Sound, Color, 14:30 Minutes, 1979

When man walked on the Moon, "live via satellite" was an extraordinary event; now it is an everyday occurence. This film depicts the present uses of satellite transmission, e.g., telephone communication, television broadcasts, televised school classes, and medical consultations for remote areas. There are presently so many satellites in geosynchronous orbit that new ways must be devised to incorporate the exciting future uses of spacecraft. These are feasible with the realization of the Shuttle. Some of these uses include computer banking by satellite, and the reproducing of whole libraries on a home video screen. A very important future prospect is a Geostationary Platform with a thirty-meter antenna, to take the place of many smaller satellites. This film is excellent for both students and adults. Lesson Guide - Appendix A.

METEOROLOGY

WIND, WEATHER AND SPACE BOOSTERS
KSC No. 161 Sound, Color, 14 MInutes, 1964

Concerns research in wind and weather, and shows methods employed to plot wind. Premise of film is how Earth atmospheric winds can affect the performance of a rocket.

KEEPING AN EYE ON GINNY
KSC No. 335 Sound, Black & White, 27:30 Minutes, 1966

This film details, in dramatic form, the contribution of Tiros satellites to accurate weather forecasting. The problem shows how the people of Chincoteague, Virginia – farmers and fishermen – relied on Tiros for information on Hurricane Ginny. Explores the process through which meteorologists develop forecasts from Tiros pictures.

HURRICANE BELOW*
KSC No. 582 Sound, Color, 14 Minutes, HQ-233-1974

The first of a series of films on disaster phenomena (caused by the elements or by man) and NASA's contribution of providing data to reduce casualities and property loss through observations from space. Lesson guide – Appendix A.

TORNADO BELOW*
KSC No. 586 Sound, Color, 15 Minutes, 1975

This film dramatically discusses and explains the weather conditions which lead to the formation of tornadoes. Emphasis is placed on the movement of air currents and the disastrous results which may follow. It shows how NASA weather satellites are used to monitor and collect data on weather conditions and cloud formation to enable us to make more precise predictions and give early warnings of impending disaster. This film is excellent for use with such topics as weather, Earth resources and space awareness. Lesson guide – Appendix A.

SURVIVAL
KSC No. 640 Sound, Color, 18 Minutes, 1977

Film opens with scenes from the 1976 Earthquake in Guatamala. It then depicts how neighboring countries and the U.S. Agency for International Development respond to the emergency. The film also shows graphic scenes from other disasters, such as floods, hurricanes, volcanoes and forest fires, and the means being taken to warn people about them. The use of satellites, such as Lageos and Landsat, to provide valuable information is covered. Suitable for general science, space awareness and public information topics and for the general public.

THE WEATHER WATCHERS
KSC No. 641 Sound, Color, 14 Minutes, 1977

Shows how NASA's weather scientists, in cooperation with other agencies, use aircraft and satellites to gather meteorological data. The film depicts how recent advances, particularly in computer technology, have improved weather analysis and prediction. Appropriate for science and space awareness topics and for the general public.

DOING SOMETHING ABOUT THE WEATHER*
KSC No. 659 Sound, Color, 14:30 Minutes, 1979

Weather just does not happen; it is caused. As this taut little film details, all three weather scales - the microphysical (tiny particles), middle (front and cells), and global (layers of atmosphere) - are interrelated in a total system One of the many benefits of the Space Shuttle will be the opportunity to test these conditions in zero gravity . In addition, the charged particles streaming into space as the solar wind can be observed and tested from a more advantageous position. This film offers a fine compendium of the causes of the weather. Lesson Guide - Appendix A.

MARS MISSIONS

THE MARTIAN INVESTIGATORS*
KSC No. 499 Sound, Color, 28 Minutes, 1969

A nontechnical presentation of Mariner 6 and 7 spacecraft that passed close to Mars in July and August 1969. Those spacecraft sent back photographs of the Martian surface and scientific data that expanded our knowledge of the planet. It features the team of scientists who planned and built the experiments and who interpreted the data sent back to Earth. Preliminary results of the mission are presented. Lesson guide – Appendix A.

MARS – THE SEARCH BEGINS*
KSC No. 574 Sound, Color, 28:30 Minutes, 1974

This film depicts the planet Mars as we now know it., from the more than 7,000 pictures taken by the Mariner 9 spacecraft. The storyline is carried by Scientists Carl Sagan, Cornell University, Gerald Soffen, NASA, and Harold Masursky, U.S. Geological Survey. The flight of Mariner, biological analysis of life on Earth and the Viking life search experiment on Mars are depicted by animation. Three-dimensional models of Martian features take the viewer onto the Martian surface. The latter were filmed with the snorkel camera system. The viewer sees Mars as we know it in 1974 and is projected into the search for life on Mars in 1976. Lesson guide – Appendix A.

WHO'S OUT THERE?*
KSC No. 587 Sound, Color, 28 Minutes, 1975

This is a dramatic presentation which discusses a view of Mars as learned from the data of Mariner missions. Also discussed are past concepts of the planet as presented by science fiction and earlier interpretations of observations made using earth-based telescopes. This film, which is narrated by Orson Wells, discusses how people have conjured up thoughts about hostile savage life forms from other planets, such as in H. G. Wells' "War of the Worlds." These old thoughts and concepts are contrasted with recent evidence of geological activity, scant mois-

ture and the rugged external features of the Martian planet as a basis for a new theory concerning the possibility of life on other planets. This film might have relevance of planetology, biology, general science and space awareness topics and for special interest groups. Lesson guide – Appendix A.

A NEW VIEW OF MARS
KSC No. 594 Sound, Color, 10 Minutes, 1975

This film very expertly gives a brief history of our concepts about the planet Mars. It presents in some detail new information about the planet and its environment learned from the Mariner 9 space misison. The information in this film is presented in a general manner which would have appeal to a broad non-technical public. In this film several references are made to unusual life forms to demonstrate peculiar adaptations to environment. The viewer should accept these as theoretical illustrations not related to proven fact.

LIFE?*
KSC No. 612 Sound, Color, 14:30 Minutes, 1975

A dramatic presentation on the characteristics of living things based on a discussion of the processes found among living organisms such as growth, nutrient procurement, digestion and assimilation. Virusus are briefly discussed as an example of organisms near the boundary between the living and the non-living. Adaptation and diversification are developed as concepts using the existence of life in hostile conditions such as high temperatures and desiccation. The film set the stage for The Viking mission to Mars and its purpose. It might be most appropriately shown with such topics as advanced general science, general biology and space awareness and to special interest groups. Lesson guide – Appendix A.

MARS – IS THERE LIFE?*
KSC No. 613 Sound, Color, 14:30 Minutes, 1975

A colorful and highly speculative film which provides a discussion of the planet Mars and its environment. The features of significance on the planet's surface are simulated and expertly narrated as background information to a discussion of the Viking Mission to determine the presence of carbon-based life. The Viking spacecraft experiment procedures are adeptly simulated and explained. This film might be most appropriate for use with general science, space awareness, and public information topics and for special interest groups. Lesson guide – Appendix A.

MARS AND BEYOND*
KSC No. 617 Sound, Color, 14:30 Minutes, 1975

Traces the Viking mission to Mars to explore for the biochemical evidence of life. Elementary chemical components of life (as we know it) are introduced. The Gas Chromotograph Mass Spectrometer on board the Viking lander is described. Film ends with potential significance of biochemical findings – how they may relate to past, present and future Martian life. Appropriate for use with general science, space science, biology and chemistry topics and for the general public. Lesson guide – Appendix A.

THE QUESTION OF LIFE
KSC no. 623 Sound, Color, 29:30 Minutes, 1976

After an interesting background discussion of life as we know it on Earth, this film outlines the probable evolution of Mars as a planet. A simulated Viking mission to Mars is depicted along with a discussion of the experiments to be conducted on the Red Planet in the search for life. Suitable for general science, biology, space awareness and public information topics and for the general public.

NINETEEN MINUTES TO EARTH
KSC No. 644 Sound, Color, 14:30 Minutes, 1977

The variety of information returned to Earth from the planet Mars by the two Viking missions is shown in this film. Included are soil and atmospheric analyses plus biological, meteorological and geological findings. Actual photographs taken by the Viking 1 and 2 spacecraft in orbit and on the surface of Mars are featured.

PLANET MARS
KSC No. 652 Sound, Color, 28:30 Minutes, 1979

Story of the exploration of our celestial neighbor. Man's fascination with Mars and the possibility of life on the planet unfolds from early investigations with telescopes to the exploration of the Viking robot lander on the Martian surface in 1976.

AERONAUTICS

A IS FOR AERONAUTICS
KSC No. 332 Sound, Black & White, 26 Minutes, 1965

The first "A" in NASA concerns aeronautical research. The film traces the American contribution to flight . . . from the Wright Brothers through the supersonic transport. The viewer meets some of the men who have made modern flight possible and sees the inner workings of a major flight research facility.

RESEARCH PROJECT X-15
KSC No. 354 Sound, Color, 27:30 Minutes, 1966

The story of the development of the X-15 research plane, plus the results obtained from X-15 flights. Dramatic photography of the X-15 flights at the edge of space and landings on dry lake beds is included.

FLIGHT TO TOMORROW
KSC No. 411 Sound, Color, 28 Minutes, 1967

This film illustrates various types of NASA aeronautical research; the development of supersonic transports, studies of hypersonic flight, vertical take-off and landing aircraft, stability of light private aircraft, jet noise reduction, and advances in aircraft safety.

FLIGHT WITHOUT WINGS
KSC No. 495 Sound, Color, 14:30 Minutes, 1969

Shows the principle of the lifting body and the progress made in its development. The craft, which obtains lift from the contour of its body, enters the atmosphere from space and flies to a pre-determined Earth landing site. The technology being developed will enable NASA to build a reusable craft that will carry men and materials to and from an Earth-orbiting space station.

AMERICA'S WINGS
KSC No. 625 Sound, Color, 28 Minutes, 1976

This film outlines the major contributions of those in aviation who have been responsible for developing improved aricraft wings. Discusses wing design problems associated with bigger, faster and heavier aircraft. Presents commentaries from some of key personnel concerned. Suitable for general science, aeronautics and physics topics and for the general public.

LIFE SUPPORT SYSTEMS

TECHNOLOGY FOR SPACECRAFT DESIGN
KSC No. 309 (Living in Space Series C) Sound, Color, 11 Minutes, 1965

Shows technology developed to enable scientists and engineers to design and build a flyable regenerative life support system for manned space missions of months or years.

A CASE FOR REGENERATION
KSC No. 310 (Living in Space Series A) Sound, Color, 12 Minutes, 1965

The film shows why oxygen and water needed for life support for manned flights into space lasting months or years must be recovered from bodily wastes. It shows how freeze-dried foods are reconstituted and the principal features that must be incorporated in a closed regenerative system that will keep crews in comfort and good health.

REGENERATIVE PROCESS
KSC No. 311 (Living in Space Series B) Sound, Color, 20 Minutes, 1965

Shows the physics, chemistry and mechanics involved in a closed regenerative life support system to support men in space for long periods of time. Also shows general operating characteristics of prototype system built and installed at Langely Research Center.

MOON FLIGHTS AND MEDICINE
KSC No. 555 Sound, Color, 25 Minutes, 1973

NASA's efforts in extending the benefits of its research in medicine have many applications. Many inventions for space have been coverted into equipment used daily by doctors, hospitals and nursing homes. This film outlines several examples of these developments.

NAVIGATION

COMPUTER FOR APOLLO
KSC No. 364 Sound, Black & White, 29 Minutes, 1966

Guidance and navigation for man's first trip to the Moon depended to a great extent on the Apollo Guidance Computer. A look at this fascinating computer - how it works, how it is assembled - is the feature of this program.

SPACE NAVIGATION
KSC No. 397 Sound, Color, 29 Minutes, 1966

Shows the problems of navigation in space, the navigational devices and techniques used for the lunar landing and developments that will enable men to land on a planet with accuracy within ten miles.

PROPULSION AND POWER

SATURN PROPULSION SYSTEMS
KSC No. 115 Sound, Color, 14 Minutes, 1964

Explanation of how the rocket's motors were developed and how they function. Shows Saturn motors being tested. Interested Junior High, Senior High and Adult.

ELECTRIC PROPULSION
KSC No. 210 Sound, Color, 23:30 Minutes, 1965

This film shows, in non-technical terms, what electric propulsion is, how it works, why it is needed, its status, the program for development, and how it may be used for both manned and unmanned space missions.

SPACECRAFT PROPULSION AND POWER
KSC No. 328 Sound, Color, 30 Minutes, 1966

Explains the sources of energy needed to propel vehicles in space. Discusses the Apollo primary and auxiliary spacecraft systems for a lunar mission. Illustrates the principles of rocket thrust and the use of liquid and solid propellants. Also describes spacecraft electrical power systems, including fuel cells, solar cells and dynamic engines.

ELECTRIC POWER GENERATION IN SPACE
KSC No. 403 Sound, Color, 27 Minutes, 1967

This film shows the wide range of power requirements for space exploration and the need for absolute troublefree operation. The methods by which electric power have been provided are shown, including the battery, solar cell and fuel cell. For higher power levels needed in the future, the various methods of using atomic energy, including two methods of generating heat and four methods of converting heat into electricity, are shown.

NUCLEAR PROPULSION IN SPACE
KSC No. 442 Sound, Color, 16 MInutes, 1968

Illustrates the principle of the nuclear rocket and the possible future use of such a propulsion system as the third stage of a Saturn V. Compares nuclear propulsion to chemical and electric propulsion for space vehicles, shows the development of the nuclear engine, and describes how such a rocket might one day be used in manned flight to another planet.

RESEARCH

HOW DID LIFE BEGIN?
KSC No. 78 Sound, Color, 20 Minutes, 1961

The film is a resume of research conducted at Florida State University. Under the auspices of NASA, on the beginning of life, and the relationship of such a study to the possibility of life on extra-terrestrial bodies. The studies center around the Darwinian Theory of Evolution. An explanation is made as to the relationship between protein and amino acids, both of which are to be found in all living matter. In the laboratory, great effort is being expended in trying to produce the aforementioned substances.

THE CHEMISTRY OF LIFE
KSC No. 79 Sound, Color, 18 Minutes, 1961

This film deals primarily with the same topic as the preceding film, "How Did Life Begin?", except that the research presented was conducted at the University of California under the direction of Dr. Melvin Calvin. The work is being sponsored by NASA. Dr. Calvin conducted much research with meteorites and the types of carbon compounds that are to be found in them. Since the basis of all organic compounds is carbon, it is hoped that clues might be found as to life on other solar bodies, as well as the beginning of life on Earth.

ADVENTURES IN RESEARCH
KSC No. 606 Sound, Color, 18 Minutes, 1975

This is a high interest level film which dramatically presents NASA research at the Ames Research Center and Kennedy Space Center. While emphasis is on the research efforts at the Ames Center, this film is exceptional in terms of presentation of its historical content and spirit of discovery. It illustrates Apollo activities, infra-red astronomy, flight simulation and computer-assisted design of experimental aircraft wing structures. The film is appropriate for use with space science, public information and Earth resources topics and for special interest groups.

TECHNICAL SCIENCE SUBJECTS

LIFE ON OTHER PLANETS
KSC No. 76 Sound, Color, 19 Minutes, 1961

This film provides a technical approach to the relatively new field of exobiology, the presence of life on extra-terrestrial bodies. Several different methods of determining the presence of life are discussed, including analysis of foreign matter that strikes the Earth (meteorites), acquisition of material from other planets (via spacecraft with return capabilities) and manned landing on other bodies in the Universe.

POETRY OF POLYMERS
KSC No. 421 Sound, Color, 19 Minutes, 1967

This film shows Dr. Frank D'Alelio of the University of Notre Dame carrying out research in polymers. The molecular structure of polymers is explained and the molding of a polymer from basic ingredients is demonstrated. The challenge of inquiring into the basic nature of materials is dramatically presented. Appropriate for use with general science and chemistry topics and for special interest groups.

X-RAY SPECTROSCOPY – THE INSIDE STORY
KSC No. 479 Sound, Color, 25:30 Minutes, 1969

Dr. Robert J. Leifield, Professor of Physics at New Mexico University, explains how X-rays are generated and how an X-ray spectrometer disperses them into a spectrum. He shows how specially grown crystals are used in a two-crystal vacuum X-ray spectrometer to diffuse an X-ray beam, isolate a single wavelength, scan a spectrum and record its characteristics.

TECHNOLOGY UTILIZATION

RETURNS FROM SPACE
KSC No. 344 Sound, Color, 27 Minutes, 1966

Depicts some of the effects the aerospace industry is having on our daily lives. It shows the earthly application of technology innovations and spinoffs from space exploration. Picture shows new perspectives in dehydrated foods, aircraft, metallurgy, hydroplaning, and laser tunnel boring. It shows the use of fuel cells in spotwelding, tractors, golf carts, and submarines. The film continues with the air-bearing technique applied to a refrigerator and air pallet. In medicine, the film displays the uses of the sight switch, advanced research for an artificial heart, clinical studies of pulmonary emphysema, and the development of the miniscope.

TECHNOLOGY UTILIZATION PROGRAM
KSC No. 507 Sound, Color, 26:45 Minutes, 1970

Describes the NASA program that insures that new technology resulting from NASA activities is brought to the attention of potential users. The film contains examples of the commercial application of technology originally developed to meet the needs of the space program.

FIVE MINUTES TO LIVE
KSC No. 602 Sound, Color, 18 Minutes, 1975

This lively and very dramatic film shows how the technology developed for space exploration benefits us in the field of medicine. The film uses the remote sensing devices developed by the space industry to show how space technology is used by paramedics to save the lives of cardiac victims in the city of Houston, Texas. This general information film is appropriate for use with general science, biology, space science and public information topics and for special interest groups concerned with advances in health care services.

PARTNERS WITH INDUSTRY
KSC No. 604 Sound, Color, 14 Minutes, 1975

This film shows how NASA technology can be used to benefit and stimulate growth and technological advances in America's industry. Examples include the heat pipes used in the construction of the Alaskan pipeline, a NASA computer language used to solve problems in design improvement of railroad freight carrier cars and the rechargeable batteries used in heart pacemakers to eliminate repeated surgery for heart patients. The film is appropriate for use with general science, public information, industrial science and space science topics and for special interest groups.

MEALS FROM SPACE
KSC No. 618 Sound, Color, 21 Minutes, 1975

Presents the testing conducted by NASA and other agencies to develop a meal system concept for those elderly persons whose diet, for a variety of reasons, is not adequate for their needs. NASA's Johnson Space Center at Houston, Texas, demonstrates how foods developed for astronaut consumption in space can be adapted for the elderly. The film shows how food is prepared, packaged, delivered and then field tested by potential users of the system. Appropriate for use with general science and social science topics and for special interest groups.

DIVIDENDS FROM SPACE – BIOMEDICAL APPLICATIONS OF SPACE TECHNOLOGY
KSC No. 643 Sound, Color, 18 Minutes, 1977

Film is concerned primarily with the activities and findings of one of NASA's Biomedical Application Teams. There is excellent footage of the team, located at NASA's Ames Research Center in California, applying space-related developments to medical problems such as heart disorders, brain injuries and cerebral palsy. Physicians involved with testing applications provide brief commentaries. Suitable for science, health and space awareness topics.

THE HOUSE THAT NASA BUILT
KSC No. 647 Sound, Color, 11:15 Minutes, 1978

Space age technology is applied to solve the problems of energy and resource conservation here on Earth. In a one-year experiment, a typical family lived in a house built by NASA and equipped with several energy-saving devices, such as solar heating and water recycling equipment. Computers monitored the entire system, keeping track of energy consumed, while sensors regulated amount of heat in the house, and were set to turn heat on and off automatically. Energy consumption was shown to be significantly reduced, due to use of solar heating.

TECHNOLOGY IN ACTION
KSC No. 649 Sound, Color, 15:30 Minutes, 1978

A presentation of spinoffs of space technology, applied to every day living. Spinoffs discussed include lighter airtanks and protective clothing for fire fighters, a self-contained water pump module for Coast Guard multipurpose vessels, a computer monitoring system to check efficiency of looms in textile mills, and wing tip vortex research applied to safer aircraft designs. Explains the NASA Technology Utilization Program and how the benefits of NASA's research can be disseminated to a wide audience through technology transfer.

DAVID'S WORLD
KSC No. 650 Sound, Color, 11 Minutes, 1979

Technology used in designing life support systems for astronauts in space is opening up a whole new world for a six-year-old boy born without the ability to fight normal germs in the air. Film shows the development of a mobile isolation suit by NASA's Johnson Space Center and Children's Hospital in Houston, Texas. Also details training sessions with parents to familiarize them with the machinery, and shows David's delight at being able to visit a playground.

ENERGY: ALTERNATIVES*
KSC No. 663 Sound, Color, 14:30 Minutes, 1979

As emphasized in this film, we do not create energy; we take it from nature. Since fossil fuels such as oil and gas are in short supply, alternative forms of energy are essential. Solar collectors and cells, windmills, heat from the earth's interior (geothermal) as well as nuclear fusion (the conversion of hydrogen atoms into helium by intense pressure) are all viable and effective producers of energy. An especially exciting prospect is that of a satellite power system which can be cost effective and a reality once the Space Shuttle is in use. This is an excellent introduction to the challenge of new ways of taking energy from nature. Lesson Guide - Appendix A.

USING SPACE RESOURCES*
KSC No. 664 Sound, Color, 14:30 Minutes, 1979

An intriguing perspective of future projects made possible by the Shuttle is discussed in this film. There is the Spacelab in which manufacturing and processing in weightlessness will become a reality. In addition, a 25-kilowatt power system will be constructed in space to provide the Shuttle with renewed power. A separate propulsion system utilizing solar energy, together with mercury, will reposition loads. To provide for a view of 80 to 140 miles above earth (important for weather observations), a tethered satellite will be deployed. In order to manufacture aluminum beams in weightlessness, a beam builder model will be positioned in space. This is a stimulating film for students and adults alike. Lesson Guide - Appendix A.

SAFETY

HAZARDS OF TIRE HYDROPLANING TO AIRCRAFT OPERATIONS
KSC No. 169 Sound, Color, 15 Minutes, 1966

Film explains the phenomenon of tire hydroplaning, under what conditions it occurs, and the resulting hazards to aircraft operations. This film, based upon tire studies at Lewis Research Center, was produced to identify and draw particular attention to a wet runway hazard which is not yet fully appreciated. The film can perhaps be used best as a training film for flight safety personnel.

AUTOMOBILE TIRE HYDROPLANING – WHAT HAPPENS
KSC No. 381 Sound, Color, 12 Minutes, 1967

Based on NASA research in aircraft safety, this film illustrates the effects of automobile tire hydroplaning, or loss of contact between

tires and wet highways. Special photography reveals the danger when hydroplaning occurs. This film was produced jointly by the Bureau of Public Roads and NASA.

TOXIC PROPELLANT HAZARDS
KSC No. 398 Sound, Color, 22 Minutes, 1967

This film has a strong safety message and is directed to personnel who have access to areas where toxic or cryogenic fuels are handled. It is a dramatic condensation of safety precautions and procedures to be used by individuals who not only work directly with the fuels but whose jobs require them to be in areas of fuel handling. The picture opens with a spectacular explosion of a rocket on a launch pad. As the flames die down, the narrator points out that the catastrophe was not the result of individual carelessness, but that it could have been. With introduction, the film moves on with dramatic demonstrations of safety precautions designed for the protection of the workers involved. The film closes with an impressive accident scene, filmed on location at Cape Canaveral, to vividly demonstrate how a small oversight can lead to potential disaster. The film further points out that propellants of the future are certain to have similar hazards but that the habits of safety developed by individuals, consistently applied, will provide adequate protection.

ANATOMY OF AN ACCIDENT – IT CAN'T HAPPEN TO ME
KSC No. 509 Sound, Color, 24 Minutes, 1970

Describes in some detail the events leading up to three accidents. Film is produced to impress workers with the importance of following the exact chain of procedures in the interest of their own safety as well as others. Dr. Kurt H. Debus, former KSC Director, introduces the film, emphasizing the responsibility of each individual for safety.

CONTROL AND RESCUE IN HYPERGOLIC FIRES
KSC No. 675 Sound, Color, 12:30 Minutes, 1983

Film shows how hypergolic propellants – those that ignite on contact with each other – are used at KSC, with an emphasis on monomethyl hydrazine and nitrogen tetroxide used to power the smaller engines on the Space Shuttle orbiter and the liquid-fueled stages of the Delta vehicle. Examines and describes the chemicals, shows firemen being trained to extinguish these types of fires, and simulates astronaut rescue operations with real propellants burning and exploding. The Space Shuttle orbiter is shown being "safed" by the removal of propellant remnants after landing.

INDUSTRIAL ARTS

THE ART OF SOFT SOLDERING
KSC No. 66 Sound, Color, 12 Minutes, 1962

This film begins by showing the complexity of modern electronic equipment and the necessity for clean soldered connections. The basic steps in good soldering are listed, and then illustrated, including the use and purpose of flux. An explanation of solder composition is given. Type, care and preparation of the soldering iron is also reviewed.

A TIP ON IRONS
KSC No. 67 Sound, Color 9 Minutes, 1962

In much the same way as the film "The Art of Soft Soldering" deals with the necessities and practices that must be followed to achieve good solder results, this movie deals with the necessity for using a good soldering iron. The film first explains what makes a good soldered connection, and the importance the iron plays in achieveing this. An explanation is given for the differences and uses of various soldering irons, the wide range of wattages, and the significance of these factors. Much time is devoted to the care and preparation of the soldering iron to extend its life and efficiency.

CERAMICS IN SPACE
KSC No. 419 Sound, Color, 19:30 Minutes, 1967

Using ceramics as a typical field of scientific study, the film shows how a graduate student develops the academic discipline needed to conduct original research. This includes the search of scientific literature; definition of the problem; design analysis; performance of experiments, collection and evaluation of data. Shows the relationship between student, faculty advisor and other scientific disciplines. Features James I. Mueller, Ph.D., professor of ceramic engineering, University of Washington.

EARTH SCIENCES

GREAT IS THE HOUSE OF THE SUN
KSC No. 422 Sound, Color, 20 Minutes, 1968

Shows the techniques used in studying the characteristics of solar radiations and their effects upon the upper atmosphere as carried out by scientists at the University of Hawaii.

CHALLENGE OF UNANSWERED QUESTIONS
KSC No. 427 Sound, Color, 15 Minutes, 1968

Presents the principal features of the Aurora, one of the most mysterious and fascinating of natural phenomena. Shows the theories of its cause and the instruments and techniques used in studying it. Shows the life and experiences of a graduate student working with Dr. Sydney Chapman at the Institute of Geophysics, University of Alaska.

A NEW LOOK AT AN OLD PLANET*
KSC No. 456 Sound, Color, 25 Minutes, 1969

The story of how space research and development is being used to help solve some of the problems on Earth. The film explores space-related techniques for discovering such things as mineral deposits, schools of fish and diseased crops. Also included are reports on how space is being used to improve world-wide communications, weather forecasting and navigation. Lesson guide - Appendix A.

SPACE IN THE 70's – SPACE DOWN TO EARTH*
KSC No. 508 Sound, Color, 27:30 Minutes, 1970

Explains Applications Technology Satellites. Describes how they will help man make more precise Earth measurements, locate new mineral resources, trace pollution, track migrating animals, make long range weather forecasts and improve navigation and communications. Lesson guide - Appendix A.

RESEARCH IN THE ATMOSPHERE
KSC No. 523 Sound, Color, 24:30 Minutes, 1971

The film reviews the techniques that have been used in studying the atmosphere since the 1600's, the evolution of ideas as to its structure and composition and the manner in which the presence of ionized helium was proved. Summarizes the techniques that have been introduced as a result of the development of rocketry, and presents the principal features of the atmospheric model published in 1965.

ERTS
KSC No. 554 Sound, Color, 27 Minutes, 1973

This film shows ten U.S. scientific investigators who explain how they are using ERTS images to identify crops, forests and grasslands; to study urban development; to determine the boundary of wetlands; to identify geological features that may lead to mineral and fuel deposits; to monitor disasters including floods and volcanic eruptions.

EARTHQUAKE BELOW*
KSC No. 595 Sound, Color, 15 Minutes, 1975

This film dramatically illustrates the cause of earthquakes such as the conditions which lead to faulting to the Earth's crust and the devastation to man and property which results. It shows how NASA Earth Resources Technology (redesignated LANDSAT) satellites are used to locate faults and help determine movement in the Earth's crust in an effort to learn how to predict quakes and give early warning. This film is excellent for use with such topics as Earth science, Earth resources and space awareness. Lesson guide - Appendix A.

POLLUTION BELOW*
KSC No. 596 Sound, Color, 14 Minutes, 1975

The contents of this film provide excellent illustrations of sources of pollution and the effects of pollution on weather and other aspects of our environment. It dramatizes the dangers of pollution to the com-

munity and its surroundings. The film illustrates how recent advances made by NASA through remote sensing satellite devices can help us to better understand, prevent, and locate pollution and its sources. The film is excellent for use with such topics as ecology, weather and atmospheric sciences, Earth resources and space awareness. Lesson guide - Appendix A.

FLOOD BELOW*
KSC No. 598 Sound, Color, 14 Minutes, 1975

This film dramatically shows how various mositure conditions can contribute to flooding and the disastrous results which can follow. Ground saturation, melting snow and precipitation are among the factors considered. It illustrates how new advances made by NASA in the field of Earth Resources Technology through remote sensing satellite devices can help locate potential flood areas and provide more accurate predictions and early warning. The film is appropriate for use with such topics as weather, ecology, Earth resources, civil defense and space awareness. Lesson guide - Appendix A.

THE WET LOOK*
KSC No. 624 Sound, Color, 14:30 Minutes, 1976

The film explores how Landsat's remote sensing capabilities help resolve water resource problems. The satellite is providing information to water engineers about the amount of snow that will provide basic water supplies to Western states. Landsat helps control floods by monitoring flood plans and by mapping snow packs and potentially dangerous man-made lakes. Landsat also makes valuable contributions in flood assessment and pollution control. Lesson guide - Appendix A.

POLLUTION SOLUTION?*
KSC No. 626 Sound, Color, 14:30 Minutes, 1976

The film discusses how Landsat's remote sensing capabilities can aid in resolving environmental quality problems. Experiments have shown that the satellite can locate strip-mining operations to facilitate land reclamation programs. The satellite helps solve some meteorological mysteries by tracking the path of airborne pollution. It can also monitor the course of industrial wastes and garbage dumped into our lakes, rivers and coastal areas. Lesson guide - Appendix A.

THE FRACTURED LOOK*
KSC No. 627 Sound, Color, 14:30 Minutes, 1976

Examine the ways in which Landsat may serve as a tool in searching for minerals and monitoring geological hazards. This Earth resources satellite can locate fractures in the Earth's outer crust. These fractures, or faults, may indicate past, present and potential volcanic and earthquake activity. Faults are also the pathways minerals used to make their way from deep within the Earth to its surface. By revealing fractures and rock alterations. Landsat imagery can aid in the exploration of minerals. Lesson guide - Appendix A.

GROWING CONCERNS*
KSC No. 628 Sound, Color, 14:30 Minutes, 1976

The film introduces the Landsat satellite as one partial solution to the world's need to survey and monitor agricultural resources. Experimentally, the satellite's imagery is supplementing ground surveys to increase the accuracy of crop production and inventory estimates in the U.S. Three governmental agencies are cooperating in LACIE, the Large Area Crop Inventory Experiment, to see how Landsat can be used to estimate crop production on a worldwide basis. By providing a comprehensive view of our timber assets, the satellite information may help improve our management in the area of forestry. Satellite imagery can also help control insect destruction of crops and trees by pinpointing infested areas for spraying. Lesson guide - Appendix A.

LAND FOR PEOPLE, LAND FOR BEARS
KSC No. 629 Sound, Color, 14:30 Minutes, 1976

Animals and people use the land for shelter, food, transportation, recreation and living. This particular film looks at how the Landsat satellite supplies a new kind of data for land-use mapping and wildlife habitat mapping. The satellite's multi-spectral scanning instruments record the spectral signatures or reflectance values, of the components of the Earth's surface. In Florida's Brevard and Orange Counties imagery is used to monitor land development. Animal biologists are using data to identify habitats for the relocation of endangered animal species. Lesson guide - Appendix A.

REMOTE POSSIBILITIES*
KSC No. 630 Sound, Color, 14:30 Minutes, 1976

The responsible management of resources on Earth is a grave concern to all its inhabitants. This film presents Landsat and its "big picture from outer space." The concept of remote sensing is explained. The satellite can provide visual imageries of our resource problem in the field of environmental quality, geology, water, land use and agriculture. The data acquired by the satellite is available to everyone to help resolve resource problems. Lesson guide - Appendix A.

IMAGES OF LIFE
KSC No. 639 Sound, Color, 25 Minutes, 1977

The film concentrates on the resources assessment capabilities offered by Earth-orbiting Landsat satellites. Special imagery from the Landsats provides a means for monitoring global conditions and expanding information on the planet's structure and resources. Landsat data is used to gain new insights into agriculture, mineral deposits, oceanography, geology and numerous other areas of concern. Examples of Landsat data in this film are worldwide in scope.

EARTHSPACE
KSC No. 642 Sound, Color, 16 Minutes, 1977

Reviews the role that changes in the Sun play in affecting the magnetosphere. Coverage includes theories of Galileo and other early scientists and recent data returned by satellites. Scientists from various universities and government agencies provided brief commentaries. Suitable for upper level science, physics and astronomy topics.

EARTHSPACE – OUR ENVIRONMENT
KSC No. 648 Sound, Color, 15 Minutes, 1978

Discusses the Earth's magnetic field, and how changes in the Sun's surface, such as sun spots, affect Earth environment. Mentions the phenomenon of the aurora in the Arctic. Explains how the Space Shuttle will carry experiments to probe the magnetosphere, and attempt to predict possible ozone layer and weather pattern changes.

NEW VIEW OF EARTH*
KSC No. 660 Sound, Color, 14:30 Minutes, 1979

X-rays provide information on invisible interiors, and satellites such as Landsat furnish otherwise inaccessible details about our planet. This film describes the operations of Landsat, a remarkable instrument for detecting pollution, forecasting earthquakes, and predicting crop yield. Unlike the eye which can observe only the visible light spectrum, the satellite's cameras observe usually invisible bands of electromagnetic radiation. The smallest area which can be detected is one acre and the light reflected back from it to the satellite is called a pixel. By combining the pixels which have been recorded in different light bands, color maps are created. The Landsat data, which is transmitted, stored and filed each day, can be requested by individuals and is readily interpreted. This film is an excellent vehicle for introducing students to the fruits of space age technology. Lesson Guide - Appendix A.

PORTRAIT OF EARTH
KSC No. 670 Sound, Color, 28 Minutes, 1981

This is a presentation that traces the evolution of satellite technology from Echo, Telstar, and Early Birds to ATS-6, Landsat, and SBS. Each of these spacecraft pioneered new practical applications for satellites. Also covered is the significant impact on weather forecasting of the GOES and NOAA series of satellites. These are capable of collecting data automatically from isolated areas, ships, and aircraft, as well as providing day and night cloud cover photographs. Specific examples of how weather satellites have improved forecasting are shown. The extensive practical applications of the Landsat program are covered, detailing benefits to farmers, the forest service, geologists, and environmentalists.

Appendix A

Film Lesson Guides

Title	Page
New Look At An Old Planet	20
Seeds of Discovery	22
Space in the 70's – Space Down to Earth	24
Mars – The Search Begins	26
Hurricane Below	28
Tornado Below	30
Conservation Laws in Zero-G	32
Zero-G	34
Gyroscopes in Space	36
Earthqu. Below	38
Pollution Below	40
Flood Below	42
Fluids in Weightlessness	44
Magnetic Effects in Space	46
Life?	48
Mars – Is There Life?	50
Mars and Beyond	52
Reading the Moon's Secrets	54
The Wet Look	57
Pollution Solution?	59
The Fractured Look	61
Growing Concerns	64
Remote Possibilities	67
Land for People, Land for Bears	70
Who's Out There?	72
The Martian Investigators	74
Shuttle Into Space	76
Live Via Satellite	78
Doing Something About the Weather	80
New View of Earth	82
The Changing Universe	84
Picture the Solar System	86
Energy Alternatives	88
Using Space Resources	90
Space Research and You . . . Your Home and Environment	92
Space Research and You . . . Your Transportation	94
Space Research and You . . . Your Health	96

New Look At An Old Planet

Title: **New Look At An Old Planet**
Subject Area: Earth Science
KSC No. 456-1969-color/sound-26 minutes
Level: upper elementary – adult

1. **Film Description:**

   Through experience in the lives of a Texas Coastal family, the film dramatizes the benefits of weather, communications, and navigation satellites. The uses of satellites in agricultural, oceanographic, and natural resources studies in the 1970s are described.

2. **Lesson Purpose:**

   This film is designed to:

   a. demonstrate the different types of spacecraft and detection systems that are used to benefit mankind.
   b. illustrate the extent of technological benefits that are generally unknown to the general public.

3. **Objectives:**

   After viewing the film the students will be able to:

   a. define the values of weather satellites.
   b. state uses and applications for communications satellites.
   c. discuss two uses for infrared photography from spacecraft and aircraft.
   d. discuss the value of relay communication between control stations and aircraft or ships at sea via satellite.

4. **Vocabulary and Definitions:**

   a. Geology – The study of the history of the Earth and its life as recorded in the rocks of Earth's crust.

   b. Meteorology – The science of weather; the study of physics of the atmosphere and its phenomena.

   c. Nimbus – A word which means "rain cloud" – the name of an experimental spacecraft largely involved with weather photography and environmental sciences.

   d. Infrared – A portion of the electromagnetic spectrum with wavelengths longer than those of visible light that is used to reveal radiation and reflection of heat energy.

   e. Earth resources – The natural organic and inorganic substances of the land that are available to man for use.

   f. Oceanography – The study of the sea, integrating all knowledge pertaining to the sea's physical boundaries, the chemistry and physics of sea water, and marine biology.

   g. NOAA – National Oceanic and Atmospheric Administration – a U.S. government agency concerned with the dynamics of the ocean and atmosphere; has responsibility for operational weather satellites.

   h. APT – Automatic Picture Transmission – a system which automatically transmits a picture from aboard a spacecraft to the Earth and is available to anyone who possesses receiving equipment.

5. **Preparatory Activities:**

   a. Conduct discussions about weather, the extent of its influence on man and the importance of accurate prediction.
   b. Discuss the problems of man's environment and what measures might be taken to better understand these problems.
   c. Discuss the concept of a satellite that would have the capability of daily observation of the Earth.
   d. List the benefits that have been derived from satellites.

6. **Presenting the Lesson:**

   a. Quickly summarize the discussions of the preparatory activities.
   b. Introduce the film by discussing the important points in its content.
   c. Ask the students to look for items that have been covered in previous class discussions.
   d. Show the film in its entirety.

7. **Follow-Up Activities:**

   a. Divide the class into groups and have them prepare short reports on selected aspects of the film content.
   b. Discuss satellites in general and list the areas in which satellites are of significant advantage and benefit to man.
   c. Consider the establishment of a school weather station.
   d. Obtain satellite photographs of your own area from the Earth Resources Observation Systems Data Center in Sioux Falls, S.D., and attempt a photo analysis of the geological, hydrological, agricultural, population, and various other aspects of the pictures.

8. **Evaluation:**

   a. Name two kinds of environmental space-borne detection systems that provide benefits to man.
   b. List three functions of weather satellites.
   c. List three functions of communications satellites.
   d. Explain infrared photography as used on spacecraft and aircraft.
   e. Give a definition for the following terms:
      (1) Nimbus
      (2) Geology
      (3) Meteorology
      (4) Oceanography
   f. Name the U.S. government agency that is primarily concerned with the dynamics of the ocean and atmosphere.

9. **Related Sources of Information** from the U.S. Government Printing Office, Washington, DC 20402:

   a. EP-84, **Satellites at Work,** $1.25
   b. EP-111, **Skylab Experiments,** Vol. 2, $1.45
   c. NF-54, **The Spectrum,** $.60
   d. NF-57, **Why Survey from Space?,** $.45

Seeds of Discovery

Title: **Seeds of Discovery**
Subject Area: Astronomy
KSC No. 503-1970-color/sound-28 minutes
Level: upper elementary – adult

1. **Film Description:**

   The film introduces planetary exploration and scientific satellite research planned for the 1970's. Described are plans for Mariner fly-bys of Mars, Pioneer studies of Jupiter, landing of unmanned spacecraft on Mars, a "Grand Tour" of the Outer Planets, and solar and other astronomical research. (Note: the "Grand Tour" was not adapted as a NASA program.)

2. **Lesson Purpose:**

   This film is designed to:

   a. illustrate man's historical quest for knowledge and understanding and the importance of the quest.
   b. acquaint the viewer with the usefulness of spacecraft in the acquisition of information.
   c. acquaint the viewer with some of the scientific knowledge already acquired by man's use of spacecraft systems.
   d. explore possible future spacecraft missions and what man might hope to learn from them.

3. **Objectives:**

   After viewing the film, the students will be able to:

   a. discuss some of man's early theories about Earth's relationship with the rest of the Solar System.
   b. state the advantages spacecraft have over conventional methods in gathering data.
   c. discuss instances in which the use of spacecraft has benefited man by increasing his knowledge.
   d. state two future uses of spacecraft for gathering information beyond Earth as defined in the film.

4. **Vocabulary and Definitions:**

   a. Magnetosphere – The region of the Earth's atmosphere in which ionized gas drawn toward Earth by its magnetic field plays an important role in the dynamics of the atmosphere.

   b. Solar winds – Streams of plasma (solar particles) flowing radially outward from the Sun.

   c. Project Viking – A planetary spacecraft program designed to place an unmanned landing craft on the surface of Mars for detection of life and gathering of data on soil and the atmosphere.

   d. "Grand Tour" concept – A plan for taking advantage of the unusual condition in which several planets are so aligned as to make it possible to visit all with a single spacecraft. The craft would use the gravity of one planet to accelerate and be directed toward the next planet in line. (NASA did not, in the end, budget a mission to take advantage of this rare alignment.)

   e. Nebula – A gigantic cloud of gas in space that is considered to be the material from which stars and planets are composed.

5. **Preparatory Activities:**

   a. Discuss the uses and advantages of spacecraft in today's modern scientific world.
   b. Discuss the concept of life beyond Earth – in the Solar System.
   c. Discuss the importance of advancing man's knowledge in today's world.

6. **Presenting the Lesson:**

It is recommended that the teacher:

a. re-emphasize the importance of expanding man's knowledge.
b. introduce the film by title and instruct the viewers to think about its meaning as they view the film.
c. show the film in its entirety.

7. **Follow-Up Activities:**

a. Discuss the meaning of the title, "Seeds of Discovery." What is meant by "seed?"
b. Assign mini-reports on various subjects, planets, and personalities covered in the film.
c. Fabricate scale models of the Sun and planets and develop illustration charts listing the important statistics of each.
d. Using a long-string and a scale of one million miles to an inch, position the planets at their proper distance from the Sun to illustrate the vast intervals between the Outer Planets.

8. **Evaluation:**

The viewers should be able to answer the following questions after completing all suggested activities:

a. State two of man's early theories about the Earth's relationship with the rest of the Solar System.
b. State two future uses of spacecraft for gathering information from beyond the Earth.
c. Explain how spacecraft have benefited man.
d. State two advantages that spacecraft have over other systems or techniques for gathering information.
e. What is the Viking Project?
f. What is meant by the "Grand Tour" concept?
g. What does the word "seeds" in the film title mean to you?

9. **Related Sources of Information** from the U.S. Government Printing Office, Washington, DC 20402:

a. EP-82, **Planetary Exploration,** $.95
b. EP-110, **Skylab Experiments,** Vol. 1, $1.25
c. EP-114, **Skylab Experiments,** Vol. 5, $1.20
d. EP-122, **Exploration of the Solar System,** $2.05
e. SP-334, **Viking Mission to Mars,** $1.20
f. SP-349, **Pioneer Odyssey: Encounter with a Giant**
g. NF-50, **The Jupiter Pioneer,** $.60

Space In The 70's - Space Down To Earth

Title: **Space in the 70's – Space Down To Earth**
Subject Area: Earth Science
KSC No. 508-1970-sound/color-27:30 minutes
Level: high school – adult

1. **Film Description:**

   The film presents the role of satellites in solving earth-bound problems. It shows what some satellites, called applications satellites, are doing now and what they can be expected to do in the future, in such beneficial areas as tracking pollution, locating mineral resources, making long-range weather forecasts, providing more precise Earth measurements, and improving navigation and communications.

2. **Lesson Purpose:**

   This film is designed to:

   a. acquaint the viewer with the wide variety of satellite systems that are available to benefit mankind through their use and applications.
   b. inform the viewer of the many problems and conditions that can be understood, improved, or corrected by use of the various satellite systems.

3. **Objectives:**

   After viewing the film the students will be able to:

   a. state at least three ways in which weather satellites can benefit man.
   b. name at least two historical uses of early communications satellites.
   c. state at least three uses for applications satellites other than weather and communications.
   d. state the advantages of using satellites over more conventional techniques for various Earth applications.
   e. describe the advantage of having a satellite in a synchronous orbit.

4. **Vocabulary and Definitions:**

   a. TIROS – Television Infrared Observation Satellite – a satellite system that is designed to take pictures of cloud cover and transmit them to Earth for weather forecasting.
   b. Nimbus – An experimental spacecraft system which is basically a weather satellite but is also used as a relay and measurement system for a wide variety of other scientific experiments.
   c. Hurricane hunters – Aircraft and crews whose job is to fly into hurricanes to make measurements of their characteristics and intensities.
   d. Geodesy – The branch of applied mathematics dealing with the determination of the shapes and areas of large parts of the Earth's surface.
   e. Computer enhancement – A process by which a computer can subtract from or intensify an image or photography to bring out information or to improve clarity.
   f. GARP – Global Atmospheric Research Program – a program, involving nations all over the world, that is attempting to produce a mathematical model of the atmosphere to assist in long-range weather forecasting.
   g. Echo – An early NASA communications satellite program using large balloons to act as mirrors in space from which signals were reflected over a great distance.
   h. INTELSAT – International Telecommunications Satellite Consortium – a group of nations around the world that operates a series of communications satellites (called Intelsats) for commercial worldwide communication purposes.

i. Synchronous orbit — An orbit at an altitude approximately 22,300 miles from Earth in which a satellite appears to stand still over one spot on Earth's surface.

j. ATS — Applications Technology Satellite — any of several spacecraft in synchronous orbit that is used for weather, communications, navigation, and other experimental purposes.

5. **Preparatory Activities:**

   a. Direct class discussions on the many problems of the world and its people with emphasis on those problems in which satellites can be useful.
   b. Discuss the idea of a satellite and how it might be used to help man to better understand and solve problems confronting him.
   c. Discuss the concept of Earth resources and what the term means to each viewer of the film.

6. **Presenting the Lesson:**

   a. Point out the problems that exist today and those that may be aided by satellite systems.
   b. Emphasize the importance of knowledge as a tool for solving problems.
   c. Point out specific characteristics of satellite systems to look for while viewing the film.
   d. Show the film in its entirety.

7. **Follow-Up Activities:**

   a. Discuss the priority of expenditures for Application Satellite Systems.
   b. Discover an Automatic Picture Transmission (APT) receiving station in your community and attempt to secure some old pictures of cloud cover which have been received by it directly from a weather satellite. Use them in class discussion.
   c. Discuss the different ways in which education could be influenced by satellites.
   d. Assign projects having to do with different types of satellite systems and their function (models, pictures, reports, displays, etc.)

8. **Evaluation:**

   The viewer should be able to answer the following questions after completing all suggested activities:

   a. Name three ways in which weather satellites can be of benefit to man.
   b. What are the advantages satellites have over conventional techniques for solving various Earth-bound problems.
   c. State three uses for applications satellites other than weather and communication.
   d. What are two historical uses of early communications satellites?
   e. What information is provided by ATS?
   f. Explain INTELSAT.
   g. What does "Earth resources" mean to you?
   h. Why is knowledge the key to solving man's problems?
   i. Explain the Global Atmospheric Research Program.
   j. What information is provided by TIROS?
   k. What benefit does synchronous orbit have?

9. **Related Sources of Information** from the U.S. Government Printing Office, Washington, DC 20402:

   a. EP-84, **Satellites at Work**, $1.25
   b. EP-111, **Skylab Experiments**, Vol. 2, $1.45
   c. NF-53, **Applications Technology Satellite — 6**, $.45
   d. NF-57, **Why Survey from Space?**, $.45

Mars-The Search Begins

Title: **Mars – The Search Begins**
Subject Area: Mars Missions
KSC No. 574-1973-color/sound-29 minutes
Level: high school – adult

1. **Film Description:**

The shrouds of Earth-based observation and speculation about the mysterious planet Mars are dispelled by the awesome discoveries of the Mariner 9 spacecraft. In addition to the numerous experiments designed to gather precise information about the Martian atmosphere and energy fields, Mariner 9's imagery systems revealed a dynamic surface containing huge volcanoes and a Rift Valley of gigantic proportions. Surface features that scientists feel could have been formed only by running water established the basis for the Viking program designed to detect life forms on Mars.

2. **Lesson Purpose:**

This film is designed to acquaint the viewer with the following:

a. modern graphic scientific description of the planet Mars and its two satellites, Phobos and Deimos.
b. comparisons between the outstanding features discovered on Mars and similar natural features that exist on Earth.
c. possibilities of life on Mars.
d. life-detection techniques that were carried aboard the Viking spacecraft that landed on Mars in 1976.

3. **Objectives:**

After viewing the film, the students will be able to:

a. name at least three outstanding unsuspected findings of the Mariner 9 spacecraft.
b. identify features of the planet Mars and the planet Earth that are similar.
c. state the reasons why scientists believe that running water once existed on Mars.
d. identify the two areas in which ice might be found on Mars.
e. identify at least one technique of life detection used by the Viking spacecraft.

4. **Vocabulary and Definitions:**

a. Extraterrestrial life – Any form of existence that is characterized by metabolism, growth and reproduction, as distinguished from inorganic or dead organic materials, and that did not originate on planet Earth.

b. Olympus Mons – A volcano on Mars, the largest known volcano in the Solar System, with a diameter of 370 miles and a height of 15 miles.

c. Valles Marineris – A great network of canyons on Mars, extending over 2,000 miles across its surface.

d. Project Mariner – A series of NASA spacecraft designed to return scientific information about Earth's neighboring planets. Four investigated Mars; the others flew by Venus and Mercury.

e. Project Viking – A planetary spacecraft program which placed two unmanned landing craft on Mars for gathering atmospheric and surface data, including the detection of any life forms present.

f. Permafrost – Water that usually lies below the surface of the soil; it is in the form of ice and never changes into a liquid or gas state.

g. Picture mosaic – A single large picture composed of several smaller pictures to show a vast land area.

5. **Preparatory Activities:**

   a. Discuss the solar system and where life might be found beyond Earth. Be sure to include Mars as the most likely place.
   b. Discuss the legendary stories of Mars and consider what forms of life, if any, might exist there.
   c. Discuss what techniques man might use to enhance his knowledge of Mars.

6. **Presenting the Lesson:**

   It is recommended that the teacher:

   a. briefly summarize the discussions conducted in the preparatory activities.
   b. show projected views of Mars and make comparisons to Earth as to size, number of moons, and other basic characteristics.
   c. show the film in its entirety.

7. **Follow-Up Activities:**

   a. Discuss the main points of the film such as discovery of volcanoes, the existence of water, and life detection.
   b. Assign groups to build an "extraterrestrial growth chamber" to simulate the environment of Mars. Stock the chamber with forms of Earth life and observe any change in them over a period of days.
   c. Fabricate a wind tunnel chamber with an observation window. Create a model made from plaster of paris to simulate the Martian surface. Cover the model with a fine grain powder and use a fan as a wind force to erode the powder away from the underlying surface. Take photographs of the simulated surface at frequent intervals and when the dust (powder) is depleted, compare the photographs to those of Mars seen in the film.
   d. Discuss the potential value of a manned voyage to Mars.
   e. Keeping in mind the physical characteristics of the planet Mars, discuss the design of a spacecraft that could land on the surface of Mars. Also, discuss the equipment necessary for investigating the surface and atmosphere of Mars.
   f. Discuss the communications problems of the Viking Project.
   g. Prepare a presentation on the Viking mission to Mars.

8. **Evaluation:**

   The viewers should be able to answer the following questions after completing all suggested activities:

   a. Name three outstanding unsuspected discoveries made by the Mariner 9 spacecraft.
   b. Compare the main features of Mars with those of Earth.
   c. Why do scientists believe that flowing water once existed on Mars?
   d. Name the two areas where water ice might be found on Mars.
   e. Name one technique of life detection to be used by the Viking spacecraft.

9. **Related Sources of Information** from the U.S. Government Printing Office, Washington, DC 20402

   a. EP-90, **Two Over Mars,** $.90
   b. EP-82, **Planetary Exploration,** $.95
   c. NF-76, **Viking Mission to Mars,** $.50
   d. SP-328, **Life Beyond Earth and the Mind of Man,** $2.00
   e. SP-329, **Mars as Viewed by Mariner 9,** $8.15
   f. SP-334, **Viking Mission to Mars,** $1.20
   g. SP-337, **The New Mars,** $8.75

Hurricane Below

Title: **Hurricane Below**
Subject Area: Meteorology
KSC No. 582-1975-color/sound-14 minutes
Level: upper elementary – adult

1. **Film Description:**

   As a crew of a trawler fish the calm waters off the coast of the Carolinas, weather satellites detect a tropical storm system that appears to be moving in their direction. Warning is quickly radioed to the residents of the threatened area and evacuation begins. The storm strikes leaving mass destruction throughout the area. As the hurricane changes course and heads back out to sea, the trawler gets underway to avoid the fury of the storm.

   This film conveys the dynamics of tropical hurricanes through a description and illustration of the causes, along with "weather and motion" pictures taken by satellites. Scenes of high winds, gigantic shoreline waves, and twisted aftermath emphasize the destructive nature of hurricanes and the need for adequate warning systems and planning procedures.

2. **Lesson Purpose:**

   This film is designed to:

   a. acquaint the viewer with the causes of a tropical storm system.
   b. emphasize the serious destructive nature of hurricanes.
   c. demonstrate the values of satellite systems in detecting and monitoring the intensity and progress of tropical storms.
   d. point out the need for heeding warnings of approaching hurricanes.

3. **Objectives:**

   After viewing the film, the students will be able to:

   a. discuss the basic causes of hurricane development.
   b. discuss the values of satellite surveys of the world's weather.
   c. discuss the potential destructive force of intense hurricanes.
   d. discuss the "eye of the hurricane" concept and the types of winds that surround it.
   e. discuss the power and destructive force of hurricane winds.

4. **Vocabulary and Definitions:**

   a. Hurricane – A cyclonic storm that develops over water with wind velocities of 75 m.p.h. or more.

   b. Hurricane eye – The center of a hurricane at which the winds abruptly become calm and skies clear. This calm period is followed by the full fury of the storm with winds in the opposite direction.

   c. NOAA – National Oceanic and Atmospheric Administration – The government organization concerned with the dynamics of ocean and atmosphere; includes the National Weather Service that uses the latest techniques to assess national and world weather.

   d. SMS – Synchronous Meteorological Satellite – a system with advanced imaging systems designed to monitor the Western Hemisphere daily from a stationary position in orbit.

   e. ATS – Applications Technology Satellite – experimental multipurpose satellites that have been instrumental in storm detection and the development of "weather in motion" studies.

   f. Cyclonic storm – A storm with strong winds rotating about a center of low pressure.

   g. Evacuation – Removal from, as in the removal of residents from a populated area threatened by severe storms.

5. **Preparatory Activities:**

   a. Direct discussions about weather and extreme atmosphere conditions and the potential dangers to life and property.
   b. Discuss the characteristics of tornadoes and hurricanes and make comparisons between the two.
   c. Discuss the role of satellites and the National Oceanic and Atmospheric Administration in weather forecasting and storm prediction.
   d. Secure satellite weather photographs from the local television or weather station and attempt to define the weather patterns. Make comparisons with a professional analysis of the photographs if possible.

6. **Presenting the Lesson:**

   a. Summarize the preparatory discussions.
   b. Site a few examples of severe hurricane disasters and present documented clippings for display on a bulletin board.
   c. Give a very brief description of the film as an introduction.
   d. Show the film in its entirety.

7. **Follow-Up Activities:**

   a. Secure hurricane plotting charts and keep a constant up-date on the progress of any storm system that may develop during the hurricane season.
   b. During hurricane season, acquire weather reports each day and plot the movement of hurricanes on a map.
   c. Produce a video tape or 8mm film of classroom students simulating a hurricane alert.
   d. Invite a professional meteorologist to address the students on the mechanics of storm development and weather forecasting.
   e. Take a field trip to a weather station for an on-the-site briefing on meteorology.

8. **Evaluation:**

   The viewers should be able to answer the following questions after completing all suggested activities:

   a. What are the causes of a tropical storm system?
   b. What is meant by the "eye of the hurricane?"
   c. Explain the values of satellite systems in relationship to tropical storms.
   d. What does NOAA have to do with hurricanes?
   e. What weather information is received from ATS?

9. **Related Sources of Information:**

   NASA Films:

   a. **Earthquake Below** (KSC No. 595)
   b. **Flood Below** (KSC No. 598)
   c. **Tornado Below** (KSC No. 586)
   d. **Pollution Below** (KSC No. 596)

   From the U.S. Government Printing Office, Washington, D.C. 20402

   a. EP-84, **Satellites at Work**, $1.25

Tornado Below

Title: **Tornado Below**
Subject Area: Meteorology
KSC No. 586-1975-color/sound-15 minutes
Level: upper elementary – adult

1. **Film Description:**

   Through the dramatization of the experience of a young pilot on her solo flight in a light aircraft, the film demonstrates the importance of accurate prediction and warning of tornado weather and the vital role played by weather satellite systems in making those predictions.

2. **Lesson Purpose:**

   This film is designed to:

   a. assist the student in understanding the importance of satellite systems and weather resources in the prediction of tornado producing weather.
   b. emphasize the destructive nature of tornadoes.

3. **Objectives:**

   After viewing the film, the student will be able to:

   a. describe conditions in the atmosphere that are favorable to the development of tornadoes.
   b. discuss the seriousness of tornado weather reports.
   c. fully recognize a funnel cloud and explain its potential threat.
   d. list three purposes of satellite pictures in the study and prediction of storm producing weather.

4. **Vocabulary and Definitions:**

   a. Tornado warning – A warning that is issued once a tornado has been sighted in the area.

   b. NOAA – National Oceanic and Atmospheric Administration – a government organization concerned with the dynamics of the atmosphere and oceans as they relate to the public interest, particularly in weather.

   c. Squall line – A line of thunderstorms caused by mixture of warm and cool air and frequently associated with tornadoes.

   d. Funnel cloud – The portion of a tornado which dips below the main cloud mass and occasionally touches the ground, causing severe damage.

   e. Baby tornado – Small tornadoes produced in the laboratory by mechanical means for scientific study of funnel cloud behavior and characteristics.

5. **Preparatory Activities:**

   a. Encourage each student to do research on tornadoes in preparation for a discussion on the subject.
   b. Discuss safety procedures during a tornado alert.
   c. Discuss the problems a community has following heavy damage by tornadoes.

6. **Presenting the Lesson:**

   a. Briefly summarize the points of the preparatory activities.
   b. Emphasize the main points of the film involving tornadoes, their detection, and aftermath.
   c. Show the film in its entirety.

7. **Follow-Up Activities:**

   a. Encourage a discussion of what procedure would be necessary to follow should your community be the victim of massive tornado damage.
   b. Make a survey of the community to determine the adequacy of proper detection warning systems.
   c. Discuss the techniques and values of tornado detection including the use of satellites.
   d. Make a map of shelter facilities to be used during a tornado.

8. **Evaluation:**

   The viewers should be able to answer the following questions after completing all suggested activities.

   a. List two sources of weather information provided to everyone.
   b. Explain how the weather service obtains its information.
   c. What is the difference between an actual tornado and a "baby" tornado?
   d. What conditions in the atmosphere are favorable to the development of tornadoes?
   e. List three environmental problems that may occur during the aftermath of a tornado.
   f. Discuss potential health or safety hazards that may result from a destructive tornado.
   g. Explain three methods for obtaining shelter from an approaching tornado.

9. **Related Sources of Information:**

   NASA Films:

   a. **Earthquake Below** (KSC No. 595)
   b. **Pollution Below** (KSC No. 596)
   c. **Hurricane Below** (KSC No. 582)
   d. **Flood Below** (KSC No. 598)

   From the U.S. Government Printing Office, Washington, D.C. 20402:

   a. EP-84, **Satellites at Work**, $1.25

Conservation Laws in Zero-G

Title: **Conservation Laws in Zero-G**
Subject Area: Skylab Science
KSC No. 589-1974-color/sound-18 minutes
Level: high school – college

1. **Educational Objectives:**

   a. The film helps students grasp the idea of angular momentum conservation. It shows and discusses a large number of examples mostly from the zero-g environment of the orbiting Skylab space station. Illustrations in space are related to more familar examples on Earth.

   b. The film shows how the spinning motion of a satellite changes to tumbling by dissipation of rotational energy while angular momentum is conserved.

2. **Prerequisites and Level of Presentation:**

   Students should have been introduced to at least one of the conservation laws – energy or linear momentum. Prior familarity with angular momentum is not assumed. The level is most suitable for advanced high school or beginning undergraduate physics students. Younger students will find the demonstrations exciting but may be baffled by the explanations.

3. **Synopsis:**

   There are three classes of demonstrations in the film.

   a. Bodies which are set spinning, rotating, or tumbling. Thereafter, they either spin steadily or change their angular velocity by modifying their moment of inertia. The angular momentum is not zero.

   b. Astronauts (and a cat) who are initially at rest but manage to change their orientation by some muscular gyration. The net angular mementum is initially zero and remains zero.

   c. Objects which are initially spinning steadily but begin to tumble because they are not completely rigid. Angular momentum is conserved, but rotational kinetic energy is converted into heat energy. As explained below, this results in a gradual change from pure spinning to a much slower tumbling.

   Moment of Inertia and Angular Momentum:

   The basic ingredients for understanding these demonstrations are the concepts of rotational inertia (or moment of inertia) and angular momentum. It is a fact of experience that rotating objects tend to keep on turning, that they conserve their "angular momentum." This is analogous to the conversation of linear momentum (mv), where m is inertial mass and v is velocity. Angular momentum can be simply expressed as

   $$L = I\omega$$

   where ω is angular velocity or speed of rotation about an axis, and I is moment of inertia. The moment of inertia of a rotating object depends not only on its mass but also on the placement of that mass relative to the rotation axis. The further the average distance of the object's mass from the axis, the harder it will be to turn (or to stop if already turning) and the larger the moment of inertia.

   In the film, a rotating wheel with movable masses is used to illustrate the concept of moment of inertia. When the masses are near the rim, it is more difficult to spin the wheel than when they are near the axle.

   With no external forces acting so as to speed up or slow down a rotating object, its angular momentum remains constant – or zero if it isn't rotating. In order for such forces to produce an angular acceleration, there has to be a net torque (force times lever arm) acting about an axis of rotation.

   Stable Rotation with Change of Moment of Inertia:

   In the film, rotating or spinning astronauts (or an ice skater) change the extension of their arms and legs. We can label the initial moment of inertia and angular velocity by I_2 and ω_1 and the final values by I_2 and ω_2. By angular momentum conservation

   $$I_1\omega_1 = I_2\omega_2$$

   If, as in the case of the ice skater, the moment of inertia is decreased by pulling in the arms, the final angular velocity must increase to keep the angular momentum constant. The same reasoning applies to the tumbling astronaut who tucks in his legs and to the pair of astronauts who draw their bodies closer together.

Turning Movements with Zero Net Angular Momentum:

In each case, some sort of counterrotation is involved – positive and negative ω's, such that the sume of all the $I\omega$'s for the particles of the turning body is zero. The lower body of an astronaut rotating his arms rotates more slowly than his arms (and in the opposite direction) because its mass and moment of inertia are much larger. In the right angle twists, there is arm and upper body movement opposite to that of the legs. The motion of the cat is more complicated, involving counterrotation of front and rear paws, arching of the back, and use of the tail.

Explorer I and the Drink Bottle:

The drink bottle and the Explorer I satellite start out spinning about the axis of minimum moment of inertia and end up tumbling about an axis of maximum moment of inertia. The explanation involves both angular momentum and energy conservation since both objects have very flexible parts which dissipate energy in the form of heat. In the case of Explorer I, heat energy is dissipated by the flexible antennae. The drink bottle was only partially filled; when it is spinning, turbulence results in conversion of rotational energy to heat.

We can express the total energy of either bottle or satellite by

$$E_T = KE + PE + Heat$$
$$= \tfrac{1}{2}I\omega^2 + PE + Q$$

Here KE is the object's kinetic energy of motion; only the rotational part is relevant. The potential energy, PE, is not involved in the onset of tumbling; it is included only because most students are familiar with the formula for E_T in this form. Since the angular momentum, $L = I\omega$, we can write the above equation in the form

$$E_T = \tfrac{1}{2}\omega\,(L) + PE + Q$$

As rotational kinetic energy is transformed to heat, Q increases while the total energy E_T remains the same. Since PE and L are also constant, the angular velocity ω decreases. In order to keep $L = I\omega$ constant, I must increase. This can only happen if the body begins to rotate about a new axis, about which the moment of inertia is greater than that of the original spin axis. As rapid spinning is gradually replaced by a slower tumbling, the transfer of energy to heat slows until the final condition of pure tumbling about the axis of maximum moment of inertial is reached and no more turbulence is generated in the fluid.

4. **Class Participation:**

Students can explain how Skylab crewmembers are able to run in a circle around the footlockers. They can also answer the question: Does this running cause the Skylab to acquire angular momentum? As a crewman runs around the inside circumference of the Workshop, the curved "track" provides an inward, centripetal acceleration of (V^2/R) meters/sec^2 or feet/sec^2. This force is exerted on the man as his feet touch the lockers and must be strong enough to provide a little friction to allow him to gain speed. (Actually, finger-and-toe holds helped get the crewman started!) Measurements show that the crewman's speed is approximately 1.5 meters per second (5 feet per second) – computed for his center of mass. At this speed, the centripetal acceleration is approximately 1.4 m/s^2 (4.5 ft/s^2) as compared to 9.8 m/s^2 (32 ft/s^2) due to gravity here on Earth. Therefore, the forces exerted on the crewmen were about 14 percent as great as on Earth, which happens to be a little less than the gravitational acceleration of the Moon. So a 68-kg (150-pound) man would feel as if he "weighed" about 9.5 kg (21 pounds) while running in Skylab at 1.5 m/s (5 ft/s), about the same as standing on the Moon's surface.

The forces exerted on each running astronaut also tend to rotate the massive spacecraft very slowly; it can acquire angular momentum. However, the astronaut also has angular momentum – he is now rotating in the opposite sense from that in which the Skylab has been accelerated. The net angular momentum of astronaut plus Skylab must remain zero since there is no external torque on the system. (In practice, the large control gyrostabilizers onboard compensated for any tendency of Skylab to rotate, as explained in the NASA film "Gyroscopes in Space.")

Students can attempt to explain the flipping of the tumbling tape recorder on Apollo 15 and the sudden flipping of the spinning nut with a rod attached – both in scenes near the end of the film. The same effect can be observed by carefully throwing a tennis racket into the air, tumbling it lengthwise. Such tumbling is unstable. It is impossible to launch the tennis racket or the recorder without giving it a small velocity about its other axes of rotation. The flipping observed is about the axis of minimum moment of inertia (long axis) while the initial tumbling is about an axis of intermediate moment of inertia (neither largest or smallest). Such tumbling is always unstable. The detailed analysis of these motions is quite complicated.

The flipping of the spinning nut with an attached rod in the film is totally mysterious – at least until it is known that the rod is a magnet under the influence of the Earth's magnetic field. This type of motion has not been calculated in detail to our knowledge. The same is true of the spring with two weights attached (a so-called Wilberforce pendulum). Any takers?

5. **Further Questions:**

   a. What are some other examples of angular momentum conservation on Earth? *(Rotation of the Earth, bicycle or other free wheel, Frisbee, person turning on a swivel chair, "bullet" football pass or any spinning or tumbling object shot or thrown in air, potter's wheel, or other flywheels used to keep heavy machinery running smoothly.)*

   b. What happens to the angular momentum of a car wheel when the car stops? *(It is returned to the Earth from which it originally came.)*

Zero-G

Title: **Zero-G**
Subject Area: Skylab Science
KSC No. 591-1975-color/sound-10 minutes
Level: junior high – adult

1. **Film Description:**

   Skylab was man's largest space station to date, and the first to support manned missions up to several months' duration. Its spacious workshop and wardroom were the scene of some spectacular demonstrations of phenomena in weightless or "zero-g" conditions. This film shows and explains many remarkable examples – and the phenomenon of weightlessness itself – in terms of Newton's laws of motion.

2. **Educational Objectives:**

   a. The film conveys an understanding of the phenomenon of weightlessness or "zero-g" in a freely falling spacecraft.

   b. The film shows and discusses some remarkable phenomena in zero-g to promote student understanding of Newton's laws of motion and gravitation.

3. **Prerequisites and Level of Presentation:**

   The film "Zero-G" is suitable for general audiences and for classroom use from junior high school to beginning undergraduate levels. Some familiarity with Newton's laws of motion and gravitation will help students understand the physical principles.

4. **Synopsis:**

   The film shows numerous demonstrations of weightlessness and crew activities in Skylab. Dr. Owen Garriott (Scientist-Pilot on the second manned mission) reflects on the meaning of these phenomena in zero-g. The university of gravitation is illustrated by scenes from the Moon including the simultaneous dropping of a feather and a hammer on Apollo 15.

   Dr. Garriott asks the provocative question, "Why did I feel weightless up in Skylab?" He corrects the naive idea that the satellite, at an altitude of only 435 kilometers (km), is beyond the Earth's gravitational pull. He gives a brief review of the basic principles of orbit and points out that Skylab and all its contents are accelerated equally by gravity so that they have no relative acceleration. The sensation of weight depends on the presence of support forces. In orbit there are none; a satellite is in steady free fall.

   The film states Newton's three laws of motion:

   a. A body remains at rest or moves with constant velocity unless acted upon by a net external force (in other words, the body has inertia).

   b. The acceleration of a body (that is, the rate change of its velocity) is proportional to the net force exerted upon it. Expressed as an equation, $F = ma = m \frac{\Delta V}{\Delta t}$ where the constant of proportionality is called the inertial mass, m.

   c. When a body exerts a force on a second body, an equal and opposite force is exerted by the second body on the first (also called the law of action and reaction).

   Striking illustrations of these laws in the zero-g environment of Skylab are shown.

   In a laboratory on the ground, frictional forces due to gravity make these laws (especially the first and second laws) much less than obvious. Devices such as the dry ice "frictionless" puck are required to demonstrate that motion in a straight line does not require the continuous application of force. In orbit, speculate that a civilization which evolved in zero-g might not have required the genius of a Newton to discover these basic laws of motion.

5. **Class Participation:**

   The film states that Skylab's orbit is a nearly circular one, 435 km (270 miles) high. With this information, students may calculate the satellite's orbital speed.

   In a circular orbit, a body with speed V has a centripetal acceleration (towards the center of the Earth) of

$$a = \frac{V^2}{R}$$

where R is the orbital radius. By Newton's second law, the product of the satellite's mass (m) and the acceleration (a) may be equated with the gravitational force

$$F = \frac{GmM}{R^2}$$

where G is the gravitational constant and M is the Earth's mass. Thus,

$$\frac{mV^2}{R} = \frac{GmM}{R^2}$$

solving for V, we obtain

$$V = \sqrt{\frac{GM}{R}}$$

The orbital radius R is very nearly equal to the Earth's equatorial radius of 6378 km, plus the orbital height of 435 km.

Therefore,

$$R = (6378 + 435) \times 10^3 = 6.813 \times 10^6 \text{ m}$$

The gravitational constant in MKS units is $G = 6.670 \times 10^{-11}$ (nt – m^2/kg^2) (known from measurements of orbital motions of the Moon and planets).

Substituting we find

$$V = \sqrt{\frac{(6.670 \times 10^{-11})\,(5.977 \times 10^{24})}{6.813 \times 10^6}} = 7650 \text{ m/sec}$$

or about 17,100 miles per hour.

6. **Further Questions:**

   a. The film states that the gravitational force on an object at the orbital height of Skylab (435 km) is 12 percent less than it would be at the surface of the Earth. How can this figure be calculated?

      Answer: *The gravitational force is proportional to the inverse square of the distance, R, to the center of the Earth. The equatorial radius R = 6378 km. On Skylab, R = (6378 + 435) = 6813 km. Thus, the ratio of forces is $(6378/6813)^2$ = .876; in other words, 12.4 percent less for Skylab.*

   b. How could you measure your body "weight" on Skylab?

      Answer: *Measure inertial mass directly using some kind of accelerated motion so that Newton's second law applies. In fact, a simple harmonic motion was used, very much like suspending a mass from a spring. The period of vibration can then be measured, and the mass is proportional to the square of the period.*

   c. We may describe free fall as a dynamic way of "turning off" gravity; moving with the acceleration of gravity, we are unable to measure it. Are there any static ways to overcome gravity? For example, are there any materials which could be placed between us and the source of the gravitational field which would shield us from the force of gravity?

      Answer: *None are known. This makes gravitation very mysterious indeed compared to an electric or magnetic field which can be shielded.*

Gyroscopes in Space

Title: **Gyroscopes in Space**
Subject Area: Skylab Science
KSC No. 592-1975-color/sound-16:30 minutes
Level: junior high – college

1. **Film Description:**

   The fascinating motion of gyroscopes is useful in everyday life and essential to aviation and space travel. This film uses gyroscope demonstrations in the "zero-gravity" of Skylab orbit to explain both principles and exotic applications.

2. **Educational Objectives:**

   a. The film acquaints students with the stability and precession of gyroscopes. The motion of a gyroscope is demonstrated in the weightless "zero-g" environment of Skylab and compared with that of gyroscopes on the ground.

   b. The film familiarizes students with numerous applications of gyroscopic motion in space travel and on Earth.

3. **Prerequisites and Level of Presentation:**

   It is desirable but not essential for students to have seen the film "Conservation Laws in Zero-g" or have been introduced to the concept of angular momentum conservation. However, the presentation is completely qualitative so that the film is suitable for junior high school through undergraduate students.

4. **Synopsis:**

   The film opens by showing many familiar examples of the stability and usefulness of rotating objects – motorcycle and bicycle wheels, tops, gyroscopes, Frisbees, aircraft instruments, etc. The importance of gyroscopic motion in aviation and space travel is emphasized in vignettes of aircraft, the Apollo Moon landing program and the Skylab space station. Safe flight and navigation require a stable platform to be established inside the aircraft or spacecraft. The craft's attitude or orientation in space is measured and controlled with respect to this gyroplatform.

   Precession is defined as motion of the rotation axis of a spinning object. Although the film does not attempt a detailed explanation of precession, it does point out that changing the direction of angular momentum of a spinning gyroscope requires the application of a torque.

   Astronaut Carr demonstrates the behavior of a small, ungimbaled (completely free) gyroscope in zero-g. The gyroscope precesses when a torque is applied with two soda straws, but the direction of this rotation is 90 degrees from naive expectation.

   Scientist-Astronaut Garriott demonstrates the behavior of a similar but pivot-mounted gyroscope on the ground. With gravity acting, the gyro precesses continually around a small pedestal and slows down due to friction of the gimbal. A large, double-gimbaled gyroscope is also demonstrated. This gyro behaves more like the small gyro in Skylab. Precession is observed only when a torque is applied with a pencil, finger, or by hanging a weight on the rotor.

   On Skylab, gyros are used to sense changes in attitude. Information from these gyros is fed into a computer which calculates and directs the application of compensating torques to three large control gyros. These torques cause precession of the massive (140-pound), high-speed control gyros, thereby holding or adjusting the orientation of the entire 100-ton Skylab. The same principles are illustrated by the operation of a gyroequipped, free-flying "Astronaut Maneuvering Unit" tested in the Skylab Orbital Workshop.

   Although a gyro in Skylab will not continually precess due to gravity, the magnetic field of the Earth can precess a spinning object if a magnet is attached. Dr. Garriott illustrates this effect with a small magnet mounted on a nut. Its spin axis is maintained at a constant angle (approximately perpendicular) to the Earth's magnetic field as the nut precesses. The magnet is never able to align itself with the Earth's field.

   The final example of a gyroscope in space is the Earth itself. Torques exerted by the Sun and Moon on Earth's equatorial bulge produce a precession of the Earth's axis in space – with a 26,000-year period (known in astronomy as the precession of the equinoxes).

5. **Appendix:**

   An Explanation of Gyroscopic Precession:

   This explanation assumes an understanding of coordinate systems and vector addition. Consider a wheel, or the rotor of a gyroscope, rotating about a shaft which coincides with the x-axis of a right-handed coordinate system (Figure 1). Let the angular momentum of the gyro be L_0, a vector initially in the +x direction. Now imagine that a couple of forces, F and F^1, is applied to the shaft in the +y and -y directions, for example, with soda straws as in the film's Skylab demonstration. The resulting torque τ (which by the right-hand rule is a vector in the +z direction) would obviously tip the gyro about the z-axis were it not spinning. Since it is spinning, we must consider the change in angular momentum produced by the torque τ. Assume that the gyro is spinning very fast so that the change in angular momentum ΔL produced by τ in a small time $\Delta\tau$ is much less than L_0 itself.

   Newton's second law, applied to rotational motion, states that the instantaneous rate of change of angular momentum is equal to the applied torque ($\tau = dL/dt$). Thus, $\Delta L = \tau\, dt$, shown in Figure 1 as a small vector in the z direction, parallel to τ. After time

Δt, the angular momentum is equal to the vector sum $\vec{L}_1 = \vec{L}_0 + \Delta\vec{L}$ which is seen from Figure 1 to be nearly equal in magnitude to $\vec{L}_0$, but rotated by an angle $\Delta\theta$ in the xz plane (about the y-axis). Therefore, the forces $\vec{F}$ and $\vec{F}^1$ have produced rotation in a direction 90 degrees from naive expectation. If the forces follow the motion of the shaft, the gyro will rotate steadily about the y-axis; this rotation is called precession.

The rate of precession $\Omega = \Delta\theta/\Delta t$ is easily calculated. Consider the triangle formed by $\vec{L}_0$, $\Delta\vec{L}$, and $\vec{L}_1$ in Figure 1. If $\Delta\theta$ is small, its value in radians is very nearly $\Delta L/L$. Thus,

$$\Omega = \frac{\Delta\theta}{\Delta t} = \frac{\Delta L}{L\Delta t} = \frac{\tau}{L} = \frac{\tau}{I\omega}$$

where I is the moment of inertia of the gyro. The relation $\tau = \Omega L$ is sometimes called the gyroscopic law. The angular momentum L appears as a proportionality constant between applied torque and precessional angular velocity. From the formula $\Omega = \tau/I\omega$, we see that a larger spin rate or moment of inertia leads to a smaller rate of precession. Conversely, as a gyro slows down, it precesses more rapidly, as pointed out by Dr. Garriott in the filmed sequence with the toy gyro on the ground.

The above description of precession is not completely correct because it does not cover the interval during which the precession begins, and it does not consider the smaller angular momentum due to the precessional velocity itself. The motion of a real gyroscope must initially involve a wobbling about the mean axis of precession, called nutation. This damps out, due to friction, too quickly to be seen in any of the demonstrations in the film.

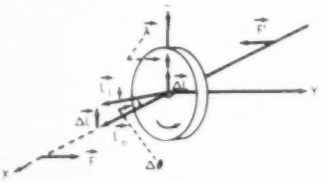

Figure 1

6. **Questions:**
   a. How does a bicycle illustrate the principle of gyroscopic motion? *When the rider leans to the right, the moving bicycle does not fall over but rather turns to the right. The front wheel has precessed in the direction of the applied torque.*
   b. How many one-degree-of-freedom gyros would be required to establish a stable platform on an airplane? *A minimum of three – one for each of the three degrees of freedom: roll, pitch, and yaw.*
   c. What uses might be found for gyroscopes on a ship at sea? *In a gyroscompass, to establish directions independent of variations in the Earth's magnetic field; also in huge stabilizers, to reduce roll and pitch.*
   d. What happens to the angular momentum of a gyroscope on the ground as it rolls down due to friction? *The angular momentum is transmitted to the Earth through the bearings and support.*

7. **Glossary:**

a.	Angular momentum conservation	– The tendency of a rotating body to continue turning at the same rate and in the same direction in the absence of an applied torque. In simple cases, if I is the rotational inertia, or moment of inertia of a body, and ω is its angular velocity, $I\omega$ is its angular momentum.
b.	Angular velocity vector	– A vector in the direction of the axis of rotation with magnitude equal to the speed of rotation.
c.	Couple of forces	– A pair of forces of equal magnitude and opposite direction acting symmetrically to rotate a body about some axis.
d.	Gimbal	– A mount, usually ring-shaped, which allows a gyroscope to spin with its axis aligned in a range of directions. A double-gimbaled gyroscope has one mount pivoted inside of another so that the spin axis has two degrees of freedom and can therefore point in any direction. (See Figure 2.)
e.	Gyroscope	– A disc, ring, or wheel which may be set spinning.
f.	Magnetic field	– Region in which magnetic forces may be acting.
g.	Magnitude	– An amount, size, or strength.
h.	Moment of inertia	– The property of a body which describes its resistance to angular acceleration. Moment of inertia depends on the mass of a body and on the placement of that mass relative to the rotation axis. A body's moment of inertia may be calculated by summing the product of each particle's mass and square of that particle's perpendicular distance from the rotation axis under consideration.
i.	Newton's First Law	– A body remains at rest or moves with constant velocity unless acted upon by an external force.
j.	Newton's Second Law	– The acceleration (instantaneous rate change of velocity) of a body is proportional to the net force acting upon it.
k.	Newton's Third Law	– When a body exerts a force on a second body, an equal and opposite force is exerted by the second body on the first.
l.	Nutation	– The wobbling of a gyroscope about its mean axis of precession.
m.	Precession	– Motion of the rotation axis of a spinning object; it will be produced by a torque exerted on the rotating object about an axis other than the spin axis.
n.	Radian	– Angular measure equal to arc length of a circle divided by its radius. Thus, a full circle of 360 degrees is equal to 2π radians. One degree = 0.017453 radians.
o.	Right-hand rule	– Rule for finding the direction of the torque vector due to a couple of forces and in numerous other applications involving vectors. The rule is to align the half-closed right hand so that the fingers follow the sense of rotation given by the two force vectors. The thumb then points in the direction of the torque.
p.	Rotor	– The spinning part of a gyroscope.
q.	Torque	– Angular analog of force. Its magnitude is given by the product of (1) the force applied to a body times (2) the perpendicular distance between the point at which the force is applied and the rotation axis. (Strictly speaking, this definition applies only when the force is applied perpendicular to the rotation axis; otherwise, the component of force perpendicular to the rotation axis is used.) The direction of torque is given by the right-hand rule and is perpendicular to the applied force.
r.	Vector	– A quantity with both magnitude and direction.

Earthquake Below

Title: **Earthquake Below**
Subject Area: Earth Science
KSC No. 595-1975-color/sound-14:45 minutes
Level: upper elementary – adult

1. **Film Description:**

This film presents an overview of the city of San Francisco explaining that the city rests on one of the most severe faults in the world. The uses of space photography and various sensing devices for locating faults and potential quake sources as well as instrumentation for quake measurements are explained. Animated and illustrative sequences are presented to portray more clearly the forces and events that cause earthquakes and tidal waves. Still pictures are used to show the effects of the 1906 San Francisco earthquake. Several scenes also show effects of the 1970 quake near Los Angeles. Scientific studies using laser beams reflected from satellites and quasar pulse measurement are also presented as future means of predicting earthquakes to provide advance warnings for populated areas.

2. **Lesson Purpose:**

This film is designed to:

a. acquaint the viewer with the basic causes of earthquakes and tidal waves.
b. show the destructive nature of earthquake shock in densely populated areas and the need for some form of earthquake prediction.
c. emphasize how satellites are used in the mapping, study, and long-term monitoring of broken and faulted areas.

3. **Objectives:**

After viewing the film, the students will be able to:

a. describe the basic causes of earthquakes and tsunamis (tidal waves).
b. describe the seriousness and severity of earthquakes.
c. describe how space photography can aid in the mapping of broken and faulted areas.
d. describe the efforts being made for future prediction of earthquakes.

4. **Vocabulary and Definitions:**

a. Earthquake – A trembling of Earth's crust caused by movement of rock masses or by volcanic shocks.

b. ERTS – Earth Resources Technology Satellite, now called Landsat – a satellite designed for taking pictures of the Earth in special energy bands to reveal specific information about the surface.

c. Fault – A break in the continuity of the basic structure of the Earth, caused by pressures beneath the Earth's surface.

d. Seismograph – An apparatus to register and measure the shocks, motions, and intensities of earthquakes.

e. Tsunami – A giant sea wave, usually resulting from an earthquake on the ocean floor, that travels from its source toward the land at speeds of up to 500 mph.

f. Prediction – A prophecy – a foretelling of future events usually based on perception of a series of existing conditions.

g. San Andreas Fault – A very large fault running almost the entire length of the state of California and out into the Pacific Ocean.

5. **Preparatory Activities:**

   a. Discuss the difficulty of predicting earthquakes in comparison to predicting other natural disasters.
   b. Discuss natural disasters with emphasis upon earthquakes.
   c. Research famous historical events concerning earthquakes.
   d. Discuss the potential causes of earthquakes.

6. **Presenting the Lesson:**

   a. Summarize the preparatory discussions.
   b. Present the vocabulary words without definitions, asking the viewers to listen for them during the film showing.
   c. Briefly introduce the film.
   d. Show the film in its entirety.

7. **Follow-Up Activities:**

   a. Review the vocabulary words immediately after the showing of the film and ask the viewers to give their definitions of the words.
   b. Secure various pictures of faulted areas and attempt to draw or trace fault features on clear acetate.
   c. Transfer acetate overlays to maps of similar scale or use pictures and features to produce fault maps of areas covered by the photos.
   d. Discuss the local terrain and determine if any faulted areas might exist.
   e. If the local area is heavily faulted, take a field trip and try to locate and photograph faulted features.
   f. Discuss and determine survival and rescue procedures should your area be striken by earthquake.
   g. Invite a speaker to discuss the phenomena of an earthquake event.
   h. Discuss the values of space-related technology in dealing with earthquake prediction. (It may be necessary to write for information about these new techniques.)
   i. Build a seismometer that can detect slight shifts of its base.
   j. Investigate important historical earthquakes and plot their locations to detect major fault systems.

8. **Evaluation:**

   The viewers should be able to answer the following questions after completing all suggested activities:

   a. Explain the basic causes of earthquakes and tidal waves.
   b. What information does ERTS, or Landsat provide?
   c. What is a fault?
   d. Explain how space photography can aid in the mapping of broken and faulted areas.
   e. Identify the efforts being made for future prediction of earthquakes.

9. **Related Source of Information** from NASA and the U.S. Government Printing Office, Washington, DC 20402:

   a. **Flood Below** (KSC Film No. 598)
   b. **Hurricane Below** (KSC Film No. 582)
   c. **Tornado Below** (KSC Film No. 586)
   d. **Pollution Below** (KSC Film No. 596)
   e. NF-57, **Why Survey From Space?**, $.45 (Government Printing Office)
   f. EP-111, **Skylab Experiments, Vol. 2: Remote Sensing of Earth Resources,** $1.45 (Government Printing Office)

Pollution Below

Title: **Pollution Below**
Subject Area: Earth Science
KSC No. 596-1975-color/sound-14 minutes
Level: upper elementary – adult

1. **Film Description:**

   The film summarizes the events involving environmental pollution that occur during a Thanksgiving Day period. It reveals a close brush with destiny for three persons with an ultimate effect on the lives of each person. Detection of pollution is observed by use of the Earth Resources Technology Satellite (now known as Landsat) and precautions are outlined to help provide solutions to the common hazards of pollution. With the new technology of spacecraft detection systems, the adverse environmental conditions can be discovered, evaluated, and monitored as conditions change.

2. **Lesson Purpose:**

   This film is designed to:

   a. acquaint the viewer with the trends of today's scientific environmental technology.
   b. show how satellites are used in the detection, study, and long-term monitoring of environmental changes, producing a new dimension in the scientific understanding of pollution.

3. **Objectives:**

   After viewing the film, the students will be able to:

   a. identify pollution sources that affect air, water, and land.
   b. state possible health hazards that may result from the pollution of air, water, and land.
   c. discuss how pollutants are detected.
   d. discuss how weather can be modified by air pollution.

4. **Vocabulary and Definitions:**

   a. Landsat – A special satellite for identifying characteristics of land and water features. It was formerly known as ERTS, Earth Resources Technology Satellite.

   b. Environment – The factors in nature that influence life and its surroundings.

   c. Pollutants – Impurities or foreign materials that affect the natural balance of an established substance or environment.

   d. Imagery – Photographs and electronic interpretations of images transmitted from satellites and other photo recording systems.

   e. Photo analysis – Interpretation of photographic images by optical or electronic means.

5. **Preparatory Activities:**

   a. Introduce the terms "environment" and "pollution".
   b. Collect pictures and other examples of pollution.
   c. Discuss local sources of pollution.
   d. Visit a water treatment plant.
   e. Discuss causes of pollution such as insecticides and oil spills.
   f. Discuss legislation that has had an effect on pollution at the local and national level.
   g. Visit sites where pollution has been minimized.
   h. Visit sites where pollution exists.
   i. Collect samples of various types of pollutants for microscopic observation in a laboratory.

6. **Presenting the Lesson:**

   a. Review the preparatory discussions and activities.
   b. Point out the following content will be seen in the film:
      (1) A global view of pollution via satellite.
      (2) Past practices leading up to current levels of pollution.
      (3) Pollution as related to potential health hazards.
      (4) Photo analysis showing land and environmental characteristics.
      (5) Weather modification caused by air pollution.
   c. Show the film in its entirety.

7. **Follow-Up Activities:**

   a. Direct a discussion immediately after the viewing to call attention to the content of the film.
   b. Answer any questions or misunderstandings that may arise concerning the content of the film.
   c. Show the film again in short segments to direct specific attention to each type of pollution mentioned in the film.
   d. Direct the viewers to specific individual or group activities to collect pictures or actual samples of pollution.
   e. After the viewers have engaged in direct learning experiences, show the film again in its entirety as a recap. This would probably be done on another day.

8. **Evaluation:**

   The viewers should be able to answer the following questions after completing all suggested activities.

   a. Name two sources of air pollution.
   b. Name two sources of water pollution.
   c. Name two sources of land pollution.
   d. Why might swimming in polluted water be hazardous to one's health?
   e. Explain how air pollution can cause storm clouds to develop.
   f. Explain how pollutants are detected on land and from space.
   g. Explain how photo analysis enables pollutants to be identified.
   h. What information does Landsat provide?

9. **Related Source of Information** from NASA, the U.S. Government Printing Office, Washington, DC 20402, and EROS Data Center:

   a. **Earthquake Below** (KSC Film No. 595)
   b. **Flood Below** (KSC Film No. 598)
   c. **Hurricane Below** (KSC Film No. 582)
   d. **Tornado Below** (KSC Film No. 586)
   e. Photographs of Pollution from Earth Resources Observation Systems Data Center, Sioux Falls, S.D. 57100
   f. EP-84, **Satellites at Work**, $1.25 (Government Printing Office)
   g. EP-111, **Skylab Experiments, Vol. 2: Remote Sensing of Earth Resources**, $1.45 (Government Printing Office)
   h. NF-54, **The Spectrum**, $.60 (Government Printing Office)
   i. NF-57, **Why Survey From Space?**, $.45 (Government Printing Office)

Flood Below

Title: **Flood Below**
Subject Area: Earth Science
KSC No. 598-1975-color/sound-14 minutes
Level: upper elementary – adult

1. **Film Description:**

   The film centers around two young ranchers who have gone into partnership in a horse ranch. While riding a horse over the ranch land, one rancher recalls the heavy snows of the preceeding winter. He observes signs of runoff from melting snow and recalls the weather forecast of potentially heavy rains that caused him to become concerned about flooding. As he rides toward the valley to spread the warning, he recalls through flashbacks events of a previous flood which devastated a valley community and nearly cost him his own life. The scenes he recalls depict the seriousness of floods and the need for advanced warning of flood conditions. Portions of the film are devoted to satellite functions that transmit information to receiving stations where it is analyzed and predictions are made concerning the potential dangers of floods.

2. **Lesson Purpose:**

   This film is designed to:

   a. acquaint the viewer with the serious consequences of flooding.
   b. demonstrate the importance of accurate data gathering procedures that utilize modern techniques and shortrange prediction of potential flood conditions.

3. **Objectives:**

   After viewing the film, the students will be able to:

   a. define the causes of a flood.
   b. discuss the dangers that a flood presents to a community.
   c. state the concept of loss suffered by victims of a flood.
   d. list the means by which modern technology can assist in determining when flood conditions are present and to what extent they have progressed.

4. **Vocabulary and Definitions:**

   a. Flood – The overflow of water from a river, lake, or some other natural source when natural boundaries cannot contain the water.

   b. Disaster – An unseen and ruinous misfortune which happens either through lack of foresight or through hostile outside forces.

   c. National Weather Service – A government agency within the National Oceanic and Atmospheric Administration with responsibility for continuously evaluating the weather, conditions of the world (primarily the United States), and relaying vital information to areas concerned.

   d. Satellite Data – Information collected by a satellite and transmitted to Earth by radio for processing into values or pictures.

   e. Flood control – Measures taken by man to control and direct the overspill of surging waters as a result of excess runoff or heavy rains.

5. **Preparatory Activities:**

   a. Initiate class discussions on flooding utilizing news clippings and articles about current flood conditions.
   b. Initiate discussions about the potential dangers of flood conditions to humans and animals as well as disaster and pollution.

c. Have the students attempt to determine the causes of floods and to suggest the visible warning signs of oncoming flooding conditions, weather forecasting, snow fall, geographical location, and river levels.

6. **Presenting the Lesson:**

   a. Review the preparatory discussions.
   b. Recall local weather, events or local geological conditions that might be conducive to flooding. Ask students to keep these in mind when viewing the film.
   c. Show the film in its entirety.

7. **Follow-Up Activities:**

   a. Following the first viewing of the film, the teacher might generate further discussions on the causes, dangers, and results of flooding, as well as prediction and control.
   b. Assign short individual or group reports on specific aspects of flooding or potential flooding.
   c. Encourage students to make an analysis of the community, town, county, or state in search of areas with a history of floods, including those that have already taken flood control measures or those that appear to be needing to take such measures.
   d. Direct the students in composing a chart of areas where floods are a problem. This might be assisted by the Landsat pictures of the area ordered from EROS Data Center, Sioux Falls, S.D., and old weather maps and Automatic Picture Transmission readouts from satellites – available from weather centers and some TV stations.
   e. Study disaster team operations such as Civil Defense or the Red Cross to develop a plan of operation for assisting victims of flooding.
   f. Take a field trip to a weather station or flood control area if available.
   g. After the first viewing of the film and the ensuing discussion, a second viewing of the film may serve as an additional guide for other follow-up-activities.

8. **Evaluation:**

   The viewers should be able to answer the following questions after completing all suggested activities:

   a. Name two contributing factors in flood conditions.
   b. Name four consequences of a flood that a community might experience.
   c. Discuss measures that can be taken to reduce losses from flood.
   d. Describe the modern technology that is available to predict flood conditions.
   e. Describe safety procedures to be employed in the event of floods.

9. **Related Sources of Information:**

   a. EROS Data Center, Sioux Falls, S.D. 57100
   b. National Oceanic and Atmospheric Administration – NOAA
   c. Civil Defense Preparedness Agency
   d. Red Cross
   e. Various insurance companies
   f. **Earthquake Below** (KSC Film No. 595)
   g. **Tornado Below** (KSC Film No. 586)
   h. **Pollution Below** (KSC Film No. 596)
   i. **Hurricane Below** (KSC Film No. 582)
   j. NASA publications from U.S. Government Printing Office, Washington, DC 20402
      (1) NF-57, **Why Survey from Space?**, $.45
      (2) EP-84, **Satellites at Work**, $1.25

Fluids in Weightlessness

Title: **Fluids in Weightlessness**
Subject Area: Skylab Science
KSC No. 607-1975-color/sound-15 minutes
Level: junior high school – adult

1. **Film Description:**

In weightlessness, the behavior of ordinary fluids is often astonishing. The collisions and splittings of liquid drops in orbital "zero-gravity" can also model systems ranging in size from an atomic nucleus to a galaxy. This film explores numerous fluid phenomena in orbit, behavior both mysterious in appearance and relevant in diverse fields of science and technology.

2. **Educational Objectives:**

a. The film conveys a qualitative and elementary understanding of fluid properties such as surface tension, cohesion, adhesion, and instability.

b. The film introduces students to the use of analogy and modeling in science by consideration of fluid drop splitting and/or merging for waterdrops, tektites, atomic nuclei, and dust cloud protostars and protogalaxies.

3. **Prerequisites and Level of Presentation:**

The discussion is entirely qualitative. Some familarity with the effect of centrifugal force would be helpful in following the explanation of rotationally induced fission. Showing of the film might be preceded by a brief discussion of how liquids differ from solids and gasses. Useful also would be simple demonstrations of waterdrop behavior on the ground; for example, throw a glass of water up in the air, observe drops forming at a water faucet, drop a little water on a very hot frying pan. The film is suitable for junior high through undergraduate students.

4. **Synopsis:**

The film opens with startling closeup demonstrations of waterdrop behavior in Skylab. Scientists-Astronaut Dr. Owen Garriott manipulates some drops. He explains why surface forces dominate the behavior of liquids in weightless conditions, using both orbital and high-speed ground photography.

Adhesion is graphically demonstrated by showing the tethering of water blobs on a string, large drops sticking to a glass rod and a drinking straw, and crewman Pogue trying out a shallow drinking "cup." Normally, astronauts drink from a squirt bottle or a hose. Although open vessels can be used, they do not appear the most practical design for life in orbit.

Large waterdrops in weightlessness (5-10 cubic centimeters) are shown, first at rest and then rotating. In equilibrium, a drop is perfectly spherical; when rotating, it assumes an elongated "dog-bone" shape. A drop will break apart if it is spun fast enough, but a unique demonstration recorded in Skylab appears at first sight to violate the laws of physics.

A stretched-out drop is seen to tumble with apparent stability for some 20 seconds before undergoing what seems to be spontaneous fission. The long delay before splitting can probably be accounted for in terms of small, irregular oscillations of the drop and the presence of an air bubble near the neck of the "dog-bone." Both of these phenomena can be seen (with some difficulty) in the slow-motion version of the event.

Several analogs to waterdrop fission are shown and discussed:

Tektites

Tektites are strange glassy rocks found exposed in Indochina, Australia, and other parts of the world. They show evidence of having once been molten and tumbling in midair. In particular, certain rare specimens have "dog-bone" shapes nearly identical to the tumbling Skylab waterdrops.

Nuclear Fission

The basic physics of fission is explained in terms of a liquid drop model. The nucleons of a nucleus as heavy as uranium attract each other like the molecules of a waterdrop. The resulting nuclear surface tension is opposed by the repulsive electrostatic forces between the protons inside the nucleus. Fission is triggered by small disturbances, such as penetration of the nucleus by a slow neutron. According to theory, the nucleus oscillates wildly, then may stretch out until it splits. Nuclear rotation is inessential to this process and is not shown in the film's simplified animated version of nuclear fission.

Clouds of Dust and Gas of Astronomical Size

Such clouds resemble fluids in their behavior. A rotating cloud may become unstable as it contracts into a disc under the influence of gravity. It may then fragment into two or more pieces. Binary, triple, and quadruple star systems probably form during further contraction and condensation of the cloud fragments. A similar phenomenon may precede the birth of solar systems like ours, in which relatively small planets carry a large portion of the angular momentum.

Some of the more detailed fluid studies on Skylab were directed at problems of crystal growth in orbit. In the so-called rotating zone method, a molten zone of silicon or germanium is cooled slowly while adhering to rotating vertical rods of the solid semiconductor. This arrangement was simulated by Scientist-Astronaut Dr. Ed Gibson, using two rotating socket wrenches and a zone consisting of several cubic centimeters (cc) of colored water adhering between them. The film shows a few of the results in extreme close-up, including some bizarre liquid oscillations and instabilities, never before recorded.

Equally strange and beautiful are the drop collisions shown. The physical analogies here are in super-heavy element formation by the collision and fusion of two heavy nuclei (at present only a theoretical possibility) and in raindrop formation by the merging of small droplets.

The film concludes with a demonstration of air bubbles injected into a rotating red water zone. Slowly the bubbles line up along the rotation axis, then merge as rotation ceases.

5. Questions:

   a. Each of the splittings of fluid drops shown or discussed in the film involves a pair of opposing forces. Students can be asked to tabulate these forces for the waterdrop, tektite, uranium nucleus, and protostar.

      waterdrop and tektite: centrifugal force outward vs. surface tension inward.

      nucleus: electrical repulsion outward vs. nuclear surface tension inward.

      protostar: centrifugal force outward vs. gravitation inward.

   b. Why did the crewmen appear to have so much difficulty keeping waterdrops from drifting all over the cabin?

      When a drop is formed with a syringe or otherwise released, it is impossible to give it exactly zero initial velocity with respect to Skylab. Also, air currents due to the cabin circulation system tend to blow the drops around.

   c. Why might microscopic water droplets form in a cloud? Once formed, how might merging take place with resulting formation of much larger raindrops?

      Warm air saturated with water vapor rises and cools by expansion, causing condensation of microscopic droplets. Eventually droplets are formed which are too heavy to be carried upward by the rising warm air. The heavier droplets fall faster, overtake and merge with lighter and smaller ones. Note: this is a highly simplified explanation; electrical forces are known to play an essential role also.

   d. Why do the air bubbles in the final rotating water zone demonstration drift toward the rotation axis? What should the bubble in the fissioning drop seen earlier do? What if iron fillings were squirted into a rotating water zone?

      The air bubbles, being lighter than water – buoyant in other words – float toward the centerline of rotation. This is almost intuitively obvious, but the following analogy should satisfy most doubters: Consider the pseudo-gravity a man or any object would feel inside a rotating cylindrical space station. Arthur C. Clarke's book "Rendezvous with Rama" has a wonderful treatment of this situation. The force of this "gravity" is directed outward. Buoyant objects, such as an air bubble in a pond, float in the opposite direction of gravitational force – upward. But in a rotating space station, or water zone, upward means toward the central rotation axis. Thus, the air bubbles in the demonstration float toward the centerline.

      The bubble inside the tumbling drop which fissions drifts toward the neck of the "dog-bone" for the same reason.

      Iron is much denser than water. Thus, the filings would drift toward the outside of the rotating zone.

Magnetic Effects in Space

Title: **Magnetic Effects in Space**
Subject Area: Skylab Science
KSC No. 608-1975-color/sound-30 minutes

1. **Educational Objectives:**

   a. Observe the characteristics of small bar magnets in a weightless environment.
   b. Calculate the strength of the Earth's magnetic field at a point 270 miles (435 km) above the Earth's surface.
   c. See a demonstration of precession* motion exhibited by rotating objects such as gyroscopes, spinning tops, planets, etc., when acted on by an external torque. In this case students will observe the precession of a spinning nut produced by the torque exerted by the Earth's magnetic field on a small magnet attached to the nut.

2. **Prerequisities:**

   Some exposure to the concepts of magnetic fields and forces and perhaps to the concept of simple harmonic motion.

3. **Synopsis:**

   Students are introduced to weightless living aboard Skylab, NASA's science laboratory, in orbit 435 km above the Earth. Dr. Owen Garriott, Skylab scientist-pilot, demonstrates the effects of the Earth's magnetic field on small bar magnets he has carried up into the space laboratory specifically to provide demonstrations of interest to teachers and students.

   Dr. Garriott shows an explains the tendency of magnets to line up with the Earth's magnetic field. Using small bar magnets, he then shows the oscillating motions (i.e., simple harmonic motion, about the magnetic field direction) of a single magnet, two magnets side by side, two magnets end to end, three magnets side by side, and three magnets end to end.

   Students are invited to time the periods of the oscillation of the different combinations of magnets. After the film, students may then – with data supplied in the guide – calculate the strength of the Earth's magnetic field at Skylab's particular location in space at the time the demonstration was performed.

   Several demonstrations are performed with a nut spinning in space, and then spinning with a small magnet attached. This demonstrates the principle of precession inherent in gyroscopes and other spinning objects acted on by an outside torque.

4. **Class Participation:**

   Measurement of Periods of Oscillation

   At a specific point in the film, Dr. Garriott invites students to measure the periods of oscillation of the four different combinations of magnets. Students making the measurement should have a stopwatch handy before the film begins.

   Calculation of the Strength of the Earth's Magnetic Field**

   The equation needed to calculate the strength of the Earth's magnetic field B is given by $B = \frac{I}{M}\left(\frac{2\pi}{T}\right)^2$ where I is the moment of the bar magnet, M is its magnetic dipole moment, and T is the period of oscillation.

   Measurements on several small magnets similar to those on Skylab give an average mass of 7.9 grams, and they are 5 centimeters in length. The moment of inertia of a bar or rod, such as these magnets, when rotated about its center of mass, is given by $I = (ml^2/12)$ kg·m^2 where m is mass in kg and l is length in meters. Also, their average magnetic dipole moment M was established to be 0.45 ampere-meter^2. The period of the single magnet shown oscillating in the film should be approximately 2 sec. We can now use the above equation and the data summarized in the table below to calculate the strength of the Earth's magnetic field at this point in the Skylab orbit.

I(kg·m^2)	M (amp·m^2)	T (sec)
1.64×10^{-6}	0.45	2.00

   The strength of the Earth's magnetic field near the equator is approximately 3×10^{-5} tesla and increases to twice this magnitude at the poles. However, these surface values decrease by almost 18 percent at the Skylab altitude of 435 km. Therefore, the computed value of B is approximately 3.60×10^{-5} tesla in agreement with what we know the magnetic field to be at the Skylab altitude.

   Similar calculations for the other cases should yield values of B in general agreement with this value to within the accuracy of the period measurements and considering that Skylab may be at any latitude between plus and minus 50 degrees.

   The following Table gives the observed oscillation periods shown in the film, and also the corresponding calculated values of B.

	Period (secs)	B (tesla)
A single magnet	2.00	3.60×10^{-5}
Two magnets, end to end	3.54	4.59×10^{-5}
Three magnets, end to end	5.41	4.42×10^{-5}
Three magnets, side by side	4.10	2.57×10^{-5}

   Calculations involving the period of precession of the magnetic and spinning nut are more difficult. However, the faster the nut is spun, the slower will be the rate of precession. It should be emphasized that it is a magnetic torque exerted on the magnets that causes both the oscillations and the precession; it is not a result of gravity. The slight "drifting motion" of the bar magnets when released by Dr. Garriott is due only to the difficulty in letting them go with absolutely zero net linear motion relative to Skylab.

*The principle of gyroscopic motion and precession is not explained in this film, but is used only to emphasize the presence of the magnetic torque. For an explanation of the behavior of gyroscopes, see the film, "Gyroscopes in Space." KSC No. 592.

**The derivation of the equation needed to calculate the strength of the Earth's magnetic field from the period of the magnets' oscillations is given in Section 6. The derivation itself is not essential to the understanding of magnetic effects in space.

5. **Further Questions:**

a. The oscillating magnet is exhibiting simple harmonic motion. What other examples of simple harmonic motion can you name? *(Pendulum, bob on a spring).*

b. Would the bar magnet oscillate faster or slower if
   (1) the bar magnet were more massive? *(slower)*
   (2) the bar magnet were a stronger magnet? *(faster)*
   (3) Skylab were in a higher orbit? *(slower)*
   (4) Skylab were in a lower orbit? *(faster)*
   (5) Skylab were circling the Moon, or Venus, or Mars? *(Not at all; the magnetic field about each of these bodies is nearly zero, a fact which, in itself alone, makes them quite different from the planet Earth.)*

c. When two bar magnets are placed end to end, their total magnetic dipole moment is approximately doubled. How should the period of oscillation change? *(It should increase by a factor of 2.)*

d. Are the oscillation periods of magnets in other configurations consistent with the equation relation B, I, M and T? *(yes)* Why do not the longer magnets (2 and 3, end to end) oscillate with exactly 2 and 3 times the period of a single magnet? *(Because Skylab had moved in its orbit to a higher latitude, therefore a stronger magnetic field region, producing a shorter period of oscillation).*

e. Does the gravitational attraction of the Earth "disappear" in an orbiting space station? If not, why is the gravitational force not felt and why is it called "0-g"? *(No, but the gravitational force is exactly offset by centrifugal force due to the orbital velocity of the space station. The net force acting on objects in orbit is zero, hence the term "0-g".)*

6. **Appendix: Calculation of the Strength of the Earth's Magnetic Field**

Let's suppose we place a small magnetic dipole (like a bar magnet) in orbit above the Earth and inclined to the Earth's magnetic field at an angle θ. The Earth's field will attempt to align the bar magnet in same direction as its own field lines, just as for a compass here on Earth. However, the floating bar magnet has no friction in pivots to damp its motion and it will "overshoot" the neutral position when aligned with the magnetic field; it simply oscillates back and forth like a (torsional) pendulum.

In the following manner, we can relate the period of its oscillation, at least approximately, to the strength of the bar magnet, its rotational inertia and the strength of the Earth's magnetic field. The torque τ exerted on a body with magnetic dipole moment M in the presence of a general magnetic field of flux density or "strength" B is given by $\tau = -MB \sin\theta$ **(Eq. 1)** where θ is the angle between the magnetic dipole moment M and the general field B (see, for example, Halliday and Resnick, **Physics**, John Wiley and Sons, 1960, pg. 698).

In the International System of Units, the torque is expressed in (newton-meter), M in (ampere-meter^4) and B in (tesla, or weber/meter^2). The negative sign in (Eq. 1) shows that when M is displaced by a positive θ, the torque is exerted in the opposite, negative direction to restore the coalignment of M and B.

We also know that whenever a torque is exerted on a body which is free to move, the body responds with a proportional angular acceleration, where the proportionality constant is the "moment of inertia", I. This allows the following relationship to be established: $\tau = I\ddot{\theta} = -MB \sin\theta$ **(Eq. 2)** where $\ddot{\theta}$ is the angular acceleration. For small oscillations, $\sin\theta \approx \theta$ and $\left(-\frac{MB}{I}\right)\theta \approx \ddot{\theta}$ **(Eq. 3)**

The solution to this differential equation is well known and describes "harmonic motion" which the dipole undergoes. It can be conveniently described with trigonometric functions: $\theta = K \sin\left(\frac{2\pi t}{T}\right)$ **(Eq. 4)** and $\ddot{\theta} = -K\left(\frac{2\pi}{T}\right)^2 \sin\left(\frac{2\pi t}{T}\right) = -\left(\frac{2\pi}{T}\right)^2 \theta$ **(Eq. 5)**

In these equations, K is a constant which expresses the amplitude of the oscillation, and T is the period of the oscillation in seconds, which is something we can measure in the experiment. By comparing (Eq. 5) with (Eq. 3), we see that

$$\frac{MB}{I} = \left(\frac{2\pi}{T}\right)^2 \text{ (Eq. 6)} \qquad \text{Thus,} \quad B = \frac{I}{M}\left(\frac{2\pi}{T}\right)^2 \text{ (Eq. 7)} \qquad \text{or} \quad T = 2\pi\sqrt{\frac{I}{MB}} \text{ (Eq. 8)}$$

We see that if the physical characteristics of the rod are measured on the ground (moment of inertia and magnetic dipole moment), a measurement of the period of oscillation (T) in space permits the calculation of the strength of the Earth's magnetic field (B) at that point in space. Note that the amplitude of the oscillation K does not affect the period of the assumed "small" oscillations.

7. **Glossary:**

a. Dipole – A north and south magnetic pole separated by some fixed distance; for example, a bar magnet.
b. Galaxy – Any large system of stars, for example, the Milky Way.
c. Gimbal – A device designed to permit a gyroscope to spin with its axis aligned about any direction.
d. Gravity – The force of attraction between bodies because of their masses.
e. Gyroscope – A disc which may be set spinning.
f. Magnetic Field – Region in which magnetic forces may be acting.
g. Magnitude – The amount, size or strength.
h. Moment of Inertia – Physical property of a body which describes its resistance to angular acceleration.
i. Orthogonal – Perpendicular to.
j. Oscillate – To swing back and forth.
k. Period of Oscillation – The time required for one complete back and forth swing.
l. Perturb – To disturb slightly.
m. Precession – Effect shown by a spinning body when acted on by an outside torque.
n. Solar Wind – The flow of particles, such as protons and electrons, outward from the sun.
o. Torque – The product of (1) the force applied to an object times (2) the perpendicular distance between the applied force and the axis about which the body may rotate.

54

Life?

Title: LIFE?
Subject Area: Mars Missions
KSC No. 612-1975-color/sound, 14:30 minutes
Level: junior high – high school

1. **Film Description:**

   The film discusses the concept of life as we know it. General characteristics of life are first described with non-life similarities noted. A number of adaptations are included to show how life has adapted to Earth conditions, and how certain individuals can withstand environmental insults. In conclusion, the habitat of Mars is described with the question raised as to the possibility of life existing there.

2. **Lesson Purpose:**

   This film is designed to:

   a. acquaint the viewer with the general characteristics of life as we know it.
   b. demonstrate the diversity of adaptations of life to environmental hardships on Earth.
   c. illustrate the general environmental conditions on Mars.
   d. acquaint the viewer with the Viking Mission to search for life on Mars.

3. **Objectives:**

   After viewing the film, the students will:

   a. Select a minimum of five characteristics of life, from the following list: (a) cellular organization, (b) organic composition, (c) locomotion (movement), (d) constant energy requirement, (e) growth, (f) reproduction, (g) life span (death), (h) response, (i) adaptations to the environment and/or the biological society.
   b. Select choices (a), (b), and (d) as accurate statements concerning water and life: (a) water is a (general) necessity for life on Earth, (b) some organisms can survive periodically without water, (c) no organism can survive when its body water is removed, (d) some organisms can survive losses of 95-100% of their internal body fluids.
   c. List a minimum of four types of organisms that can survive harsh environmental conditions: (a) rotifers, (b) roundworms, (c) water bears, (d) bacteria.
   d. Select choices (b) and (c) as valuable reasons to search for life on Mars: (a) because Mars is very similar to the Earth, but not polluted, (b) because we might be able to still better understand life, and ourselves, (c) because we might be able to extend our knowledge into the unknown, (d) because Mars is such a hot planet with a thick atmosphere.
   e. List the following characteristics of Mars: (a) water in form of frost in the evenings, (b) intense ultra-violet radiation from the Sun, (c) thin atmosphere, (d) surface winds 250-300 mph.
   f. Recognize that the Viking Mission marks the search for life elsewhere in the solar system.

4. **Vocabulary and Definitions:**

   a. virus – Noncellular particle that requires the presence of living tissue for reproduction.
   b. organic – Refers to a compound containing carbon.
   c. adaptation – Adjustment to conditions in an environment.
   d. habitat – Place and conditions in which an organism lives.
   e. water bear – Common name for Tardigrade, an organism with four pairs of legs having retractable claws; it commonly lives on the surface of mosses.
   f. rotifer – Member of phylum Trochelminthes or Rotifera; "wheel animals" with rows of cilia around the mouth, an apparatus to grind food, and a forked grasping foot.
   g. bacteria – Members of phylum Schizomycophyta Kingdom-Protista; cells lack an organized nucleus; they reproduce by fission or endospores.
   g. stentor – Trumpet-shaped protist in phylum Ciliophora, a ciliate.
   i. ameba – A single-celled protist in phylum Sarcodina; locomotion by change of state from sol to gel.
   j. roundworms – Members of Nematoda phylum; slender, elongated, and unsegmented worms.

k. hydra – A freshwater coelenterate; possesses stinging cells (nematocysts) that can paralyze organisms up to the size of small fish.

l. tentacles – Long appendages of a hydra; possess stinging cells (nematocysts).

m. Viking Mission – NASA mission which placed unmanned landing craft on the surface of Mars to search for evidence of life and recorded surface and near-surface data.

5. **Preparatory Activities:**

a. Have students prepare reports on the virus; how it is like a "living chemical"? Why is it considered life? Why is it considered non-life?

b. Discuss the characteristics that living things share. Discuss the concept of a "partial definition" of life when considering life from only one or two characteristics. Conclude by having students compile their own definition of living organism in as few words as possible. Discuss their definitions.

6 **Presenting the Lesson:**

a. Briefly summarize preparatory discussions.

b. Show film in its entirety.

7. **Follow-Up Activities:**

a. Take a field trip into a nearby wooded habitat and collect mosses from the base of trees, along trails, etc. (If a field trip is impossible, have students bring in as many moss samples as possible, a minimum of fifteen samples, favoring tree mosses.) Carefully wash the dirt from the base of the plants and turn them upside down into containers of water. Allow 24-48 hours minimum for the organisms to settle into the water. Gently wring out the leaflets and examine the water for the presence of roundworms, rotifers, and water bears. Isolate these organisms and **slowly** allow their water to evaporate over several days. Experiment on their resistant states; variables can include temperature, salt, light, etc. Also study the cryptobiotic state in which these creatures can survive in a near death-like condition. Add water at the conclusion of the experimentation; give up to 48 hours for the organisms to become active. Attempt to make conclusions quantitatively as to percentages of variables these organisms can withstand. Relate the value of such resistant states when living in the film of water that covers moss leaflets.

b. Obtain brine shrimp eggs (sometimes called "sea monkeys") from local aquarium shops. Hatch in an ocean water mix. Observe development of the brine shrimp within different salinities. Compare to their ability to survive in a habitat that would destroy most organisms.

c. Obtain cactus plants and examine their root systems. How have desert plants adapted to an existence in small amounts of moisture? Diagram their root systems, stems, and leaves.

d. Discuss various adaptations of desert creatures to survive in a habitat lacking moisture. Consider desert mice, spiders, camels, burros, lizards, prairie dogs, snakes, plants, etc.

e. Have students report on bacteria that exist in hot springs, within arctic temperatures, and in extremely saline conditions. Also discuss seeds in Egyptain pyramids that have sprouted after thousands of years. How could these examples relate to the possibility of life elsewhere in our solar system?

f. Have students prepare reports on the physical characteristics of Mars. Hold discussions on the kinds of life that might exist in such conditions.

8. **Evaluation:**

Prepare a test from the objectives.

9. **Related Sources of Information** from the U.S. Government Printing Office, Washington, DC 20402:

a. EP-50, **Space Resources for Teachers: Biology**, $3.25

b. EP-82, **Planetary Exploration**, $.95

c. EP-113, **Skylab Experiments, Vol. 4, Life Sciences**, $1.45

d. SP-328, **Life Beyond Earth and the Mind of Man**, $2.00

e. SP-334, **Viking Mission to Mars**, $1.20

f. NF-76, **Viking Mission to Mars**, $.50

Mars -- Is There Life?

Title: **Mars – Is There Life?**
Subject Area: Mars Missions
KSC No. 613-color/sound-14:40 minutes
Level: junior high – high school

1. **Film Description:**
   Students are introduced to the possible past history of Mars, as well as its present surface topography. The Viking Lander and its biology experiments are discussed in relation to the search for life.

2. **Lesson Purpose:**
   This film is designed to:
   a. acquaint the viewer with the general surface features of Mars.
   b. emphasize the biology experiments aboard the Viking Lander.
   c. explore the past history of Mars.
   d. assist the student in understanding the search for life on Mars.

3. **Objectives:**
   After viewing the film the students will be able to:
   a. List a minimum of four of the following Martian features/conditions: (a) "dust-storms," (b) dried-up river beds, (c) polar (ice) caps, (d) canyons, (e) volcanoes, (f) impact craters.
   b. Select choice (b) as the most accurate statement concerning Martian volcanoes (a) all Martian volcanoes are small compared to the size of Earth volcanoes, (b) the largest known volcano is on Mars, (c) the smallest known volcano is on Mars, (d) most Martian volcanoes are still active, (e) volcanoes do not exist on Mars.
   c. Select choice (c) as the best answer in regard to the presence of water on Mars: (a) water is presently in two large lakes, (b) there is absolutely an absence of water on Mars, (c) at times there has been flowing water, but today the water is largely ice or frost, (d) water has always been in the form of ice on Mars, (e) water has never been in the form of ice on Mars.
   d. Select choice (e) as the accurate statement concerning Martian canyons: (a) canyons do not exist on Mars, (b) Martian canyons are only a few miles wide, (c) Martian canyons may extend for 200 miles, up to 500 miles only, (d) Martian canyons are small compared to canyons on Earth, (e) Martian canyons are much larger than any canyons on Earth.
   e. Reply "false" to the statement: "If the biology experiments do not indicate life on Mars today, then there is absolutely no chance that life exists on Mars."
   f. List the following features that may have been in the past history of Mars (according to present evidence): running water and active volcanoes.
   g. In describing the biology experiments aboard the Lander, note five of the following characteristics: (1) utilize carbon 14 to trace materials through life processes, (2) involve providing food (or sunlight) for possible organisms, (3) involve an atmosphere of carbon dioxide, (4) involve small to large amounts of water, (5) involve gases being given off by the organisms present, (6) involve photosynthetic or metabolic processes, (7) involve chemical detectors to determine the presence of life.
   h. Select choice (d) as the most accurate answer in regard to the kinds of organisms the Viking biology experiments seek to detect: (a) only extremely large organisms, (b) only plants, (c) only animals, (d) microscopic animals and plants, (e) only larger animals.

4. **Vocabulary and Definitions:**
   a. Volcanic activity – Volcanoes and molten materials at the planet's surface and subsurface, as well as associated disturbances.
   b. Impact craters – Surface craters created by the impact of solar system debris attracted by a heavenly body.
   c. Martian "duststorms" – Winds of 250-300 mph that generally last two to three days on the surface of Mars, moving large amounts of dust.
   d. Polar caps – Polar bodies of water, ice and frozen carbon dioxide that vary in size during the Martian year.
   e. Viking Lander – The landing craft of the Viking Mission to Mars.
   f. Mars – The fourth planet out from the sun; planet most like Earth in the solar system.
   g. Carbon 14 – Radioactive tracer isotope used to identify carbon through metabolic or photosynthetic processes.
   h. Chemical detectors – Equipment aboard Lander specifically designed to identify chemicals.

5. **Preparatory Activities:**
   a. Have students research Mars from early knowledge to recent discoveries. How have man's views changed through time?
   b. Have students discuss how they would search for life on Mars.

6. **Presenting the Lesson:**
   a. Briefly summarize discussions of preparatory activities.
   b. Show the film in its entirety.

7. **Follow-Up Activities:**
   a. Compare student suggestions for searching for life on Mars to NASA's biology experiments.
   b. Prepare models of Mars, using clay, papier-mache, or other substances; compare to Earth.
   c. Present position papers about the possibility of life on Mars or elsewhere in the solar system/universe.
   d. Discuss the evolution of Mars and compare to the evolution of Earth.
   e. List and discuss Earth organisms that might be able to survive the environmental conditions on Mars.
   f. Diagram and compare each of the three biology experiments.

8. **Evaluation:**
   Prepare a test from the objectives.

9. **Related Sources of Information:**
   NASA Films: See listing under Mars Missions.
   From the U.S. Government Printing Office, Washington, DC 20402:
   a. SP-334, **The Viking Mission to Mars**, $1.20
   b. SP-337, **The New Mars**, $8.75
   c. EP-50, **Space Resources for Teachers: Biology**, $3.25
   d. EP-82, **Planetary Exploration**, $.95
   e. EP-90, **Two Over Mars**, $.90
   f. NF-76, **Viking Mission to Mars**, $.50

Mars and Beyond

Title: **Mars and Beyond**
Subject Area: Mars Missions
KSC No. 617-color/sound-14:30 minutes
Level: junior high – high school

1. **Film Description:**
   Students are introduced to the possibilities of life in the solar system, from Mercury to Pluto. Major emphasis is on Mars and the Viking mission to investigate life there. The organic analysis instrument is specifically discussed.

2. **Lesson Purpose:**
   To acquaint the viewer with the following:
   a. planets in the solar system
   b. purpose and function of the organic analysis instrument
   c. possibility of life within and beyond the solar system
   d. Viking Mission to search for life on Mars

3. **Objectives:**
   After viewing the film, the students will be able to:
   a. Select choice (c) from the following, as the planet most likely to possess life as we know it: (a) Mercury, (b) Pluto, (c) Mars, (d) Venus.
   b. List five out of seven planets that probably do not possess life as we know it: Mercury, Venus, Jupiter, Saturn, Uranus, Neptune, Pluto.
   c. Describe the function of the organic analysis instrument, including: (a) soil is vaporized, (b) vapor passes through column, (c) molecules and atoms of vapor are accelerated, (d) accelerated particles fall into collection plates, (e) machine identifies substances present.
   d. Select choice (d) as the major biochemical components of life as we know it: (a) oxygen, potassium, (b) hydrogen, helium, argon, oxygen, (c) oxygen, argon, copper, (d) oxygen, hydrogen, carbon, nitrogen, (e) oxygen, nitrogen, silicon, aluminum.
   e. Recognize that the energy for life in the solar system as we know it originates from the Sun.
   f. Describe the Viking Mission as the initial step for searching for life elsewhere in the solar system.

4. **Vocabulary and Definitions:**
   a. Spores – Asexual reproductive cells of less advanced forms of life; often extremely resistant to environmental extremes.
   b. Atom – The smallest unit of an element that retains the characteristics of the element.
   c. Molecule – The smallest combination of atoms in a substance that retains the properties of the substance.
   d. Organism – A complete (or entire) living thing.
   e. Carbonhydrate – A substance composed of carbon, oxygen, hydrogen; produced by plant life on earth.
   f. Lipid – A fat or oil; an organic compound found in earth life.
   g. Protein – A complex carbon based substance that is found in the nuclear materials of life as we know it; composed of carbon, hydrogen, oxygen, nitrogen, also sulfur and phosphorus.
   h. Organic analysis instrument – A gas chromatograph – mass spectrometer (GCMS) that separates gases of a substance and is able to identify the components.
   i. Asteroids – Group of minute planets that are primarily situated between Mars and Jupiter.
   j. Viking Mission – NASA project investigating the possibilities of life on Mars.

5. **Preparatory Activities:**
   a. List foods students consume in a particular day on the blackboard and organize the foods into similar groups; eventually identify three major groups: carbohydrates, proteins, and lipids (fats and oils). Discuss each substance and its relationship to life.
   b. Have students identify and discuss the elements on the periodic table that are absolutely essential to all life as we know it.

6. **Presenting the Lesson:**
   a. Summarize discussions of preparatory activities.
   b. Show the film in its entirety.

7. **Follow-Up Activities:**

a. Make models of the planets in the solar system; discuss the characteristics of each.

b. Diagram the two components of the organic analysis instrument: the gas chromatograph and mass spectrometer. Discuss purpose and function. (The gas chromatograph can be compared to individuals running the mile; at the finish they will be strung out since each runner (or substance) travels at a particular speed.)

c. Hold discussion on the kinds of life that may have existed on Mars in the past, or may exist in the present or future.

For Chemistry Teachers:

d. Consider the conditions which prevail upon the planet Mars. The night-time temperatures are approximately -123° in some localities. The atmospheric pressures are low, but may be as much as 4.7 torr in some of the lower lying regions. If life, as we know it, does exist, then what substances would be found? Consider the following list of substances which are biochemically related to living systems or their by-products.

1. acetic acid
2. adenine
3. adenosine tri phosphate
4. alanine
5. ammonia
6. amylose
7. carbon dioxide
8. cellulose
9. cetyl palmitate
10. chlorophyll
11. chlosterol
12. cystenine
13. cytosine
14. glucose
15. guanine
16. hexacosanyl palmitate
17. hexanol
18. hippuric acid
19. hystidine
20. lactice acid
21. maltose
22. methane
23. stearic acid
24. threonine
25. triolein
26. tristearin
27. uracil
28. water

This list is merely a sampling of biochemically related substances. Using some convenient reference work, try to classify these substances according to the following categories: (1) Substances which would not be found in solid samples taken from the Martian surface (unless trapped within the surface or formed as a decomposition product during pyrolysis). (2) Substances which might be found in the solid Martian samples. (This category may be further divided into the following categories: (a) Substances which would decompose when heated to 200° in the gas chromatographic column. (b) Substances which would either vaporize or decompose when the column was heated from 200° to 482°C.)

e. Classify these substances into their general biochemical classification: lipids, carbohydrates, amino acids (as well as polypeptides and proteins), nucleic acids and nucleotides, porphyrins, alcohols, fatty acids, biochemically related, although not necessarily organic.

f. Because most biochemically active substances are decomposed by heating, determine the typical decomposition products for some of the examples categorized.

8. **Related Sources of Information:**

NASA Films: See listing under Mars Missions.

From the U.S. Government Printing Office, Washington, DC 20402:

a. SP-334, **The Viking Mission to Mars,** $1.20

b. SP-337, **The New Mars,** $8.75

c. EP-50, **Space Resources for Teachers: Biology,** $3.25

d. EP-82, **Planetary Exploration,** $.95

e. EP-87, **Space Resources for Teachers: Chemistry,** $2.95

f. EP-90, **Two Over Mars,** $.90

g. NF-76, **Viking Mission to Mars,** $.50

Reading the Moon's Secrets

Title: **Reading the Moon's Secrets**
Subject Area: Apollo Program
KSC No. 631-1976-color/sound, 16 minutes
Level: junior high – adult

1. **Introduction:**

The film begins with a brief review of the six trips man has taken to the Moon and the directions the student is expected to follow while viewing the film. Starting with a view of the full Moon and a picture of a young boy with a telescope looking at the Moon, the student is visually taken on a quick trip to the Moon. This zoom-in technique uses telescopic pictures, pictures from lunar-orbiting spacecraft and the Apollo programs, as well as pictures taken in a scientific laboratory. The visual trip doesn't stop at the surface but goes "inside" the Moon rocks, by using pictures taken by scientists during their study of the rocks.

The pictures showing the crystals in a thin slice of rock show brillant colors. The colors arise from the breaking up of polarized light by different minerals in a thin slice ("thin section ") of a lunar basalt.

The primary intent of this section is to get the film started and to emphasize one major point. The Moon is made of the same elements and atoms as the Earth and the rest of the solar system.

Question: Are the atoms making up the Moon the same kind of atoms we find on Earth? Answer: yes or no.

Answer: *The answer is yes. The Moon does not contain any new kinds of atoms or elements.*

2. **Traveling to the Moon:**

This section focuses on the reasons we sent men to the Moon. The section shows the launch of Apollo 17 followed by a view of astronauts working in space while traveling to the Moon, the landing sequence of the lunar module, and an astronaut leaving the lunar module.

Question: Your second question is related to the problem of why explore the Moon. Men were sent to the Moon:
(a) because of man's curiosity to explore the Moon when he had the opportunity.
(b) in order to learn the answers to fundamental scientific questions about the Moon.
(c) in order to demonstrate American technological ability.

Answer: *All answers are correct. Your class and some students may insist that one answer is the best. However, all of the answers are valid, and the preference of one answer over another is largely a matter of personal choice.*

3. **Life on the Moon:**

The question of whether life as we know it existed on the Moon was thought to be settled long before man went to the Moon. However, scientists did not want to take a chance that the unexpected – life on the Moon – might be overlooked. Therefore, an intensive search was made for lunar organisms and an extensive quarantine program was provided for the first astronauts to return from the Moon.

It might be worth pointing out to your students that some scientists were concerned whether the quarantine program was sufficient to prevent any organisms, if they existed, from finding their way into the Earth's environment. Fortunately, no life forms, injurious or benign, were found on the Moon.

Question: Scientists were hoping to find evidence of life in lunar rocks because such evidence might:
(a) provide clues to the early development of life forms.
(b) supply us with new kinds of plants.
(c) provide clues to new forms of life that might be found on Earth.

Answer: *The best answer is (a). Scientists believe that life may have evolved from purely inorganic material acted upon by heat, radiation, or other natural phenomena. Thus it was considered possible that the processes out of which living organisms evolved might have begun on the Moon and been arrested at some stage more primitive that the complex life forms found on Earth.*

4. **Time Scale:**

Of the many surprising results discovered in lunar exploration one of the most remarkable is the extreme age of the lunar rocks. This find was unexpected by many scientists because most comparable Earth rocks are much younger. We had no way to measure accurate ages of lunar features until lunar material was returned to Earth for study.

It is the intent of this section to focus the student's thought on just how old the lunar rocks are compared to those we find on Earth. Apparently, the earliest rocks found in the Earth's crust have by now been destroyed by movements of the crust and erosion; at least, their isotopic clocks have been reset.

Question: Does this mean that the Moon is older than the Earth?

Answer: *The answer is no. Scientists believe that the oldest rocks on Earth have probably been destroyed or altered through natural processes.*

5. **Surface Features on the Moon:**

The student is led to think about surface features found on both the Moon and the Earth. The students should be relatively well informed about the origin of many surface features found on the Moon. He should think about the possibility that the Earth, too, was bombarded by meteorites. This may be a new idea to some students.

Question: Do you think that the lunar surface features were formed in the same way as Earth surface features?

Answer: *The answer is no. It is worthwhile to point out that the Earth does have impact craters. Meteor Crater in Arizona was formed by impact. Only within recent years have many other impact craters been discovered. Most surface features on the Earth have been formed by crustal movements and modified by the interaction of the atmosphere and water on rock materials.*

6. **Some of the Lunar Rocks:**

Here the student must consider processes that apply to both the Moon and the Earth. The primary objective is to develop the idea that both Moon and the Earth rocks have certain things in common. However, specific differences in processes that modify the rocks are evident.

The question is intended to accentuate the similarities and differences.

Question: Did the astronauts find any materials that we can say are similar to sedimentary materials found on Earth?

Answer: *The answer is yes. The material collected in the drive tube and scoop shows that broken up rock material exists on the Moon. Rock material of this type makes up sedimentary rocks on Earth.*

7. **The Composition of the Moon:**

This section begins with a reminder that the Moon and the Earth are composed of the same elements. In fact, plants will grow in contact with lunar soils. However, the relative amount of the different elements is not the same for both the Earth and Moon.

Help your students recognize that understanding the composition of the Moon provides many clues to the origin of planetary bodies. The material in depth will provide additional help.

Question: The Moon's composition is different from that of Earth because:
(a) all of the elements from on Earth were not present when the Moon was formed.
(b) the Moon formed under different conditions than the Earth.
(c) we haven't collected enough samples from the Moon to really know about its composition.

Answer: *The answer is (b). However, our sampling of the Moon is somewhat limited so we must be concerned about (c) as well. Scientists have long known that the average composition of the Earth was different from those of other planets. It is now believed that the distinctive concentrations of elements in the Moon and the Earth are due to different conditions under which these bodies formed.*

8. **The Interior Structure of the Moon:**

Here is the most challenging test of your student's imaginations. The pictures develop the idea that gigantic crustal plates move slowly over the Earth's surface. However, the Moon shows no evidence of this kind of large-scale motion. The major objective of this section is to establish why this difference in crustal activity exists.

Question: On Earth we have evidence of continental drift; on the Moon, no evidence of crustal drift. How come?
(a) The Moon does not have an inner metallic core.
(b) The Moon's crust is so thick and solid it can't move.
(c) The moonquakes are too weak to fracture the Moon's crust into plates.

Answer: *The answer is (b). Your students may argue with the answer. For example, choice (c) is true, but it doesn't fully answer the question. Evidence from seismic studies supports choice (b).*

9. **Weathering and Erosion of the Lunar Surface:**

Studies of lunar rocks returned by astronauts show that the rocks change when exposed to the environmental conditions found on Earth. The rocks must be stored in a pure nitrogen atmosphere. This section contrasts the different environmental conditions that exist on the Moon and the Earth.

Question: Do you think that the lunar rocks weather and erode?

Answer: *The answer is yes. This question does not ask for whether the weathering and erosion processes on the Moon and the Earth are similar, but whether the rocks in both places weather and erode.*

10. **The Moon's Past and Its Future:**

Here we develop the concept that changes in the lunar rocks and surface take place very slowly. This is one of the highlights of the film because the pictures are spectacular and the ideas challenge the imagination.

Question: Does this mean that the Moon's surface:
(a) will remain unchanged in the future?
(b) changes very slowly?
(c) in some places does not change at all?

Answer: *The answer is (b). Discussion of this question should bring out an important idea that is not explicitly developed. Because the Moon's surface changes so slowly – relatively small changes in the last 3 billion years – scientists consider the Moon's present state somewhat analogous to early conditions found when Earth formed. It is as though we are looking at the conditions that Earth encountered before it developed a protective atmosphere.*

The lunar surface features were produced mainly by meteoroid bombardment and lava flows. The meteoroid that so intensely bombarded the lunar highlands had mostly been swept up before the less intensely cratered lunar maria formed. The source of meteoroids large enough to change major lunar features is apparently very depleted, so that the expected rate for such changes has become vanishingly small. Furthermore, any molten material within the Moon is too deep to reach the surface. Thus, major changes in the appearance of the Moon are not to be expected on a time scale of hundreds of millions of years.

Weathering and erosion: On Earth processes that degrade the surface rocks slowly but surely are results of the action of wind and water. There are slow erosional processes that occur on the Moon as well. The most active of these is bombardment of the lunar surface by micrometeorites (meteoroids of microscopic size). The collision of particles from the solar wind is also believed to contribute somewhat to the slow grinding away of lunar rocks. This may be part chemical weathering as solar wind ions react with the outermost layers of atoms in the rocks. These processes are responsible for removing approximately 1 millimeter from the surface of a rock every million to 10 million years. Thus, most rocks that are thrown out onto the lunar surface by collisions of meteoroids are destroyed within 100 million years.

During Apollo 17, samples were taken from a boulder at the base of the large hill known as the North Massif. A long track in the soil extended from the boulder well up the side of the hill to the rock outcrop from which the boulder came. When the boulder broke away, it exposed a large, fresh rock surface. From studies of the damage done to the fresh surface by cosmic rays, it is known that the boulder fell from the hill 20 some million years ago. In all that time, the track left in the soft lunar soil has not been obliterated!

11. **Secrets for Study in the Future:**

The narration at the end focuses on the fact that while we know a great deal about the Moon, there is still more to learn. Students should recognize that scientists have not discovered all of the Moon's secrets.

Studies of nearby planets – Mercury, Venus, and Mars – should reveal exciting discoveries. Clearly, a great number of secrets of the solar system remain to be discovered. Point out to your students that the exploration of the Moon is only a beginning and not an end to scientific discovery of our neighbors in space.

The Wet Look

Title: **The Wet Look**
Subject Area: Earth Science
KSC No. 624-color/sound-14:30 minutes
Level: junior high – high school

1. **Film Description:**

   "The Wet Look" explores how Landsat's remote sensing capabilities help resolve water resource problems. The satellite provides information to water engineers about the amount of snow that falls enabling them to estimate the basic water supply for Western states. Landsat helps control floods both by monitoring flood plains and by mapping snowpacks and potentially dangerous man-made lakes. Landsat also makes valuable contributions in flood assessment and pollution control.

2. **Lesson Purpose:**

   "The Wet Look" is designed to:

   a. acquaint viewers with the satellite Landsat and its remote sensing capabilities;
   b. define existing water resource problems;
   c. illustrate ways in which Landsat imagery may help resolve those problems;
   d. challenge students to identify possibilities for personal involvement in water resource concerns.

3. **Objectives:**

   After viewing the film, the students will be able to:

   a. discuss the importance of controlling our water resources.
   b. define ground truth and discuss its importance in comparison to Landsat images.
   c. state how Landsat is aiding in flood control.
   d. list three kinds of conditions that cause floods.
   e. discuss how Landsat is used to help us manage water resources more wisely.

4. **Vocabulary and Definitions:**

   a. Landsat – A satellite that collects and relays global resource data by means of remote sensing.
   b. Remote sensing – The means by which scanning instruments aboard Landsat detect and record the nature of objects on Earth.
   c. Spectral signature – The distinct arrangement of reflected visible and infrared light of any object, recorded in red, blue and green ranges.
   d. Imagery – The "picture" that results from remote sensing.
   e. Ground truth – Actual developments or conditions as observed on the ground of a specific area, compared to Landsat imagery to check validity of photo interpretation.

5. **Preparatory Activities:**

   Have students prepare reports on water-related crises, such as a flood, a drought, or a brown-out. Consult your library **Reader's Guide to Periodical Literature** for resource information such as: "Back to Dustbowl Days"/TIME, August 12, 1974; "Biggest Flood in Years"/US NEWS & WORLD REPORT, April 23, 1973; and "New York's Utility Crisis"/NEWSWEEK, August 18, 1969.

6. **Follow-Up Activities:**

   a. Local Water Problems – Find the source of water for your area. Make a list of potential water problems where you live and invent a way that satellite pictures could be used in preventing them.

b. Neighborhood Mapping – Find out if there are bodies of water in your neighborhood that do not appear on maps. Make your own "satellite map" of water bodies in your area. Draw them as you think they would look from space.
c. Reservoir Control – Hydroelectric plants depend on a steady source of power. On a steam table make a reservoir with an uphill water source. Have the water controls hidden. With someone changing the water flow, learn how to use the reservoir so that the flow below it is always the same. Can you control the flow if you do not know how much water is coming from uphill?

7. Evaluation:

Create a water problem, or use one that the class has studied. Divide the class into groups and assign each group a different role in the resolution of the chosen problem. Role-play, trying to solve the problem using Landsat imagery. For instance, if the problem were a brown-out, some of the group might be: local businessmen and families who use electricity, the reservoir management, the utility company, Landsat information office, Landsat scientists, water engineers, etc.

8. Related Sources of Information:

NASA Films:

a. **The Wet Look** (KSC No. 624)
b. **Pollution Solution** (KSC No. 626)
c. **The Fractured Look** (KSC No. 627)
d. **Growing Concerns** (KSC No. 628)
e. **Land For People, Land For Bears** (KSC No. 629)
f. **Remote Possibilities** (KSC No. 630)
g. **ERTS-Earth Resources Technology Satellite** (KSC No. 554)

From the U.S. Government Printing Office, Washington, DC 20402:

a. NF-54, **The Spectrum**, $.60
b. NF-57, **Why Survey From Space**, $.45
c. 2401-2060, **Studying The Earth From Space** (Dept. of Interior), $.35
d. SP-360, **Mission to Earth; Landsat Views the World**, $14.00

Sources of Landsat Imagery:

Scenes imaged by Landsat 1 and 2 are available for purchase by the general public from:

a. User Services Unit
EROS Data Center
Sioux Falls, South Dakota 57198

b. National Cartographic Information Center
U.S. Geological Survey
507 National Center
Reston, Virginia 22092

c. U.S. Geological Survey
Branch of Distribution
1200 South Eads Street
Arlington, Virginia 22202

Pollution Solution?

Title: **Pollution Solution?**
Subject Area: Earth Science
KSC No. 626-color/sound 14:30 minutes
Level: junior high – high school

1. **Film Description:**

"Pollution Solution?" explores how Landsat's remote sensing capabilities can help resolve environmental quality problems. Experiments have shown that the satellite can locate and monitor strip-mining operations to facilitate land reclamation programs. Landsat helps solve some meteorological mysteries by tracking the path of airborne pollution. It can also monitor the course of industrial wastes and garbage dumped into our lakes, rivers, and coastal areas.

2. **Lesson Purpose:**

"Pollution Solution?" is designed to:

a. acquaint viewers with the Landsat satellite and its remote sensing capabilities;
b. introduce Landsat as a tool for detection of pollution sources and as a potential monitor for pollution "clean-up" enforcement;
c. challenge student to identify possibilities for personal involvement in environmental pollution concerns.

3. **Objectives:**

After viewing the film, the students will be able to:

a. list five reasons why it is important to those living on the Earth to be able to control the quality of our environment.
b. discuss the positive and negative factors of strip-mining and how Landsat can assist in land reclamation projects.
c. explain the relationship between particles of smoke released from Lake Michigan steel mills and unusual amounts of snow on the opposite shore and how Landsat imagery confirmed this.
d. list five causes of water pollution and explain how Landsat imagery might aid us in solving pollution problems.

4. **Vocabulary and Definitions:**

a. Landsat – A satellite that collects and relays global resource data by means of remote sensing.
b. Remote sensing – The means by which scanning instruments aboard Landsat detect and record the nature of objects on the Earth.
c. Spectral signature – The distinct arrangement of reflected visible and infrared light of any object, recorded in red, blue and green ranges.
d. Imagery – The "picture" that results from remote sensing.
e. Strip-mining – The process by which top layers of Earth are stripped off and coal underneath exposed and dug out.
f. Reclamation – The method by which land that has been damaged in some way, such as by strip-mining, is restored.
g. Meteorologist – A scientist who studies the weather.
h. Cloud seeding – Introduction of foreign particle(s) into clouds to induce precipitation.
i. Eutrophication – The process in which large amounts of fertilizing chemicals are introduced into an ecosystem, upsetting its natural life-death cycle.

5. **Preparatory Activity:**

Have students check newspapers and magazines for articles related to the environmental pollution issue. Hold class discussion on these articles.

6. **Follow-Up Activities:**

a. Cloud Seeding – Cut a heavy-duty balloon so that it can fit tightly over the mouth of a pint jar. Use epoxy glue to fasten a plastic thread spool to the center of the balloon, securing the balloon-lid with rubber bands so that it can be removed. Set the jar on a dark surface. Breathe into the jar, then seal it. Pull up the spool; a faint cloud *may* form. Now remove the lid and blow out a match over the opening. Catch a little smoke inside the jar and seal it again. When the spool is pulled up this time, a definite cloud should form. Students should explain their observations. Can they discover the mechanism of cloud seeding?

b. Euthrophication – To study the kinds of effects over-fertilization (of phosphates and nitrates) has on the oxygen content of water: use some dry powdered yeast, powdered milk, and methylene blue solution. Mix a teaspoon of yeast with 20cc water. In another jar, mix one teaspoon milk with 20cc water. Set up three test tubes with the following mixtures:

TEST TUBE	YEAST	MILK	WATER	METHYLENE BLUE
1	0cc	– – –	5cc	10 drops
2	1cc	1cc	3cc	10 drops
3	1cc	5cc	– – –	10 drops

Record the time needed for a color change in each test tube. (Methylene blue is colorless in the absence of oxygen.) Students should explain the results and associate each part of the experiment with an element of a pollution event in a river.

c. Pollution Map – Contact county conservation and urban development offices for information which will help students make a regional map showing possible sources of pollution, types, and extent. How much pollution travels outside of the neighborhood? To where? How much pollution originates in your region? How could someone find out?

7. **Evalution:**

Divide the class into three groups: one representing the first settlers in your area, another, a contemporary citizens' group, and the third, Landsat scientists. Using a medium pertinent to each group's time period, describe the community's environmental quality. For example, the settlers could print a town gazette, the citizen's group might stage a TV public service announcement or design a series of graphics. Perhaps the "scientists" would hold a press conference, complete with Landsat image mock-ups. Let the groups discuss how the quality of their home environment has changed, discover the sources of pollution problems, and develop ideas for solving those problems. (May be tied in to "Pollution Map" activity, above.)

8. **Related Sources of Information:**

NASA Films:

a. **The Wet Look** (KSC No. 624)
b. **Pollution Solution** (KSC No. 626)
c. **The Fractured Look** (KSC No. 627)
d. **Growing Concerns** (KSC No. 628)
e. **Land For People, Land For Bears** (KSC No. 629)
f. **Remote Possibilities** (KSC No. 630)
g. **ERTS-Earth Resources Technology Satellite** (KSC No. 554)

From the U.S. Government Printing Office, Washington, DC 20402:

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U.S. Geological Survey
507 National Center
Reston, Virginia 22092

c. U.S. Geological Survey
Branch of Distribution
1200 South Eads Street
Arlington, Virginia 22202

The Fractured Look

Title: **The Fractured Look**
Subject Area: Earth science
KSC No. 627-color/sound 14:30 minutes
Level: junior high – high school

1. **Film Description:**

"The Fractured Look" examines the ways in which Landsat may serve as a tool in searching for minerals and monitoring geological hazards. This Earth Resources Satellite can locate in the Earth's crust fractures or faults that may indicate past, present, and potential volcanic and earthquake activity. Faults are also the pathways minerals use to make their way from deep within the Earth to its surface. By revealing fractures and rock alterations, Landsat imagery can aid in man's exploration for mineral resources.

2. **Lesson Purpose:**

"The Fractured Look" is designed to:

a. acquaint viewers with the Landsat satellite and its remote sensing capabilities;
b. define some existing geological problems;
c. introduce Landsat as a detection tool in the search for minerals and the monitoring of geological hazards;
d. stimulate viewers' interest in using remote sensing to study Earth geological patterns and problems.

3. **Objectives:**

After viewing the film, the students will be able to:

a. explain why Landsat is a useful tool in mapping faults.
b. describe how Earth fractures are related to earthquakes.
c. discuss the connection between faults and minerals near the Earth's surface.
d. state the advantages of utilizing Landsat imagery in mineral exploration.

4. **Vocabulary and Definitions:**

a. Landsat – A satellite that collects global resource data by means of remote sensing.
b. Remote sensing – The means by which scanning instruments aboard Landsat detect and record the nature of objects on the Earth.
c. Spectral signature – The distinct arrangement of reflected visible and infrared light of any object, recorded in red, blue and green ranges.
d. Imagery – The "picture" that results from remote sensing.
e. Fault/fracture – A break in the continuity of a body of rock, with shifting dislocation of the body's elements along the plane of the break.
f. Geologist – A scientist who studies the physical history of the Earth, the rocks composing it, and the physical changes it undergoes.
g. Magma – Molten rock located far below the Earth's surface.

5. **Preparatory Activity:**

Have students research one of the following:

a. the history of man's search for precious minerals, such as alchemists or the California miners of 1848.
b. the historical records of famous fault-related phenomena, such as the volcanic eruptions of Vesuvius or the San Francisco earthquake of 1906.

6. **Follow-Up Activities:**

a. Using a fault map, locate any fractures in your area. Address inquiries for these kinds of maps to: United States Geological Survey, Geological Inquiries Group, Mail Stop 907, National Center, Reston, Virginia 22092.

b. Model Fractures – A fault is a fracture along which movement of the sides has occurred. Demonstrate the types of fractures by building a model: take a block of wood, 6" x 4" x 5" – paint strata around the outside. Make a diagonal cut in the wood, containing strata lines along the revealed sections of the block.

Using the blocks, demonstrate the following faults:

a. normal (gravity) fault – hanging wall has dropped in relation to foot wall.
b. reverse (thrust) fault – hanging wall has been pushed upward in relation to foot wall.
c. transcurrent (strike-slip) fault – movement has taken place in a horizontal direction along fracture.

To check your results compare with diagrams in an Earth Science or Geology text book. Can you determine which type(s) of fault is/are in your are?

c. Selective Crystallization – Mix equal volumes (about 1 tablespoon each) of these salt combinations in water: 1) potassium chlorate and potassium chromate and 2) potassium permanganate. Put each of the mixtures in a wide-mouthed test tube and let stand. As evaporation occurs, causing denser concentration of salts, observe crystallization take place. Note how the varying degrees of solubility result in the layering of the colored crystals, much like rock banding.

d. Simulated Volcano – Build a small model volcano: make cone of heavy manila-folder paper, 3" in diameter at the base, and 4" tall. Coat cone with thick (about 1") layer of plaster of paris. When dry, dig a 1" crater in tip of cone. Place model on asbestos sheet. Charge the crater with 50-60g. ammonium dichromate, with a 2" magnesium tape fuse. Light the tape. (The charge of ammonium dichromate may be increased to as much as 250g.)

Can a volcano happen in your area? Remember the tectonic plate theory, which indicates volcanoes occur only along converging plate boundaries.

7. **Evaluation:**

The viewers should be able to answer the following questions after completing all suggested viewing activities:

a. Why is Landsat a useful tool in mapping faults?
b. How are Earth fractures related to earthquakes?
c. Why can faults be called the "pathway of minerals"?
d. How does modern science show that old-time prospectors were correct in looking for gold where they did?
e. How can Landsat help in mineral exploration?

8. **Related Sources of Information:**

NASA Films:

a. **The Wet Look** (KSC No. 624)
b. **Pollution Solution** (KSC No. 626)
c. **The Fractured Look** (KSC No. 627)
d. **Growing Concerns** (KSC No. 628)
e. **Land For People, Land For Bears** (KSC No. 629)
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Branch of Distribution
1200 South Eds Street
Arlington, Virginia 22202

70

Growing Concerns

Title: **Growing Concerns**
Subject Area: Earth Science
KSC No. 628-color/sound 14:30 minutes
Level: junior high – high school

1. **Film Description:**

"Growing Concerns" introduces the Landsat satellite as a partial solution to the world's need to survey and monitor agriculture resources. Landsat's imagery is being used experimentally to supplement ground surveys in an effort to increase the accuracy of estimates of crop production and inventory in the U.S. Three U.S. government agencies are taking part in LACIE, the Large Area Crop Inventory Experiment, to see how Landsat can be used to estimate crop production on a worldwide basis. The satellite may also help improve our management of timber by providing a comprehensive view of our forest lands. In addition, Landsat can also help control insect destruction of crops and trees by pinpointing infested areas for spraying.

2. **Lesson Purpose:**

"Growing Concerns" is designed to:

a. acquaint viewers with the Landsat satellite and its remote sensing capabilities;
b. illustrate the worldwide need for greater control of our agriculture resources;
c. introduce Landsat as a potential tool for international management of food, fibre and timber production;
d. challenge viewers to discover other possibilities for Landsat imagery application.

3. **Objectives:**

After viewing the film, the students will be able to:

a. state one major reason for an international food crisis, and to discuss the planning needed to attack the problem.
b. explain how Landsat is experimentally being used to improve accuracy in estimating crop distribution and production.
c. list results of Landsat experiments done in the U.S. and the possibility of applying on a worldwide basis.
d. relate what part Landsat plays in the multi-agency experiment called LACIE (Large Area Crop Inventory Experiment).
e. discuss the importance of managing our timber resources wisely and how Landsat imagery can help.
f. describe how Landsat imagery helps in the fight against insect infestation.

4. **Vocabulary and Definitions:**

a. Landsat – A satellite that collects and relays global resource data by means of remote sensing.

b. Remote sensing – The means by which scanning instruments aboard Landsat detect and record the nature of objects on Earth.

c. Spectral signature – The distinct arrangement of reflected visible and infrared light of any object, recorded in red, blue and green ranges.

d. Imagery – The "picture" that results from remote sensing.

e. Inventory – A cataloging of all items in a particular group, e.g., an account of all crops on a farm.

f. Surplus – An excess; that remaining when a need is met.

g. Vegetation – Plant life or total plant cover.

h. Extrapolate – To project or extend known data of a familiar area to achieve estimates of the same kind of data in an unfamiliar area.

i. LACIE (Large Area Crop Inventory Experiment) – A U.S. government effort to combine multi-agency information on soils, climate and crop acreage to arrive at total crop production estimates for large areas, with a minimum of ground truth.

j. Defoliate – To strip (a plant) of its leaves.

5. **Preparatory Activities:**

a. Place soil 5cm deep in 3 small flowerpots, labeled 1, 2, and 3. Moisten the soil. Plant 5 radish seeds in each pot. Place pots where each is exposed to same heat and light conditions. Put a dish under each pot. Water seeds regularly from the top until leaves appear. (This will be tied in with a Follow-Up Activity.)

b. Have each student start a window vegetable garden at home, in a container not to exceed the size of a shoebox. (These will be tied in with a Follow-Up Activity.)

6. **Follow-Up Activities:**

a. Environmental Differences – Undetected or ignored differences in environments can lead to unanticipated crop results – and failures. Bring out Pots 1, 2, and 3 from Preparatory Activity (a), above. Leave Pot 1 uncovered. Cover Pot 2 with clear plastic bag held in place with a rubber band. Stand two wooden matches into Pot 3's soil; light them. As the matches burn, slip a clear plastic bag over Pot 3 – carefully! Secure the bag with a rubber band. The matches will die out, leaving smoke over the seedlings. Water the three regularly from the bottom. Observe plants each day for three weeks, keep a record of changes. Draw conclusions from what you see. If the three pots were three large pieces of cultivated land, and the smoke was smog, how would Landsat's "big picture from outer space" make a difference in crop prediction?

b. Classroom (Food) Crisis – Ask students to bring in their window gardens started as Preparatory Activity "C". Have them discussed their methods of cultivation and consequent yields.

Remember the formula used in the LACIE experiment:

number of acres x yield per acre = total production

Consequently, for your project:

number of cm's x yield per cm = total production of all window gardens

How could you have increased productivity? What is the similarity between this staged "crisis" and the real one that exists today?

c. Infrared Photography and Plants – Using a 35mm camera and some Kodak high spool infrared film, check out the "spectral signatures" of similar plants. Compare these photographs to those of artificial, diseased and insect-infested plants.

Photograph a group of trees with infrared film (avoid shooting into a shadow). What are the visible differences between the trees? What differences are revealed in your photos?

Grow a radish garden in a window box – vary the soils, and water with vinegar (to simulate an acid rain). At intervals, document growth with infrared photography. Note visible differences as well.

7. **Evaluation:**

Divide your class into ten major world areas: North America, South America, Europe, USSR, Middle East, Africa, China, India,

72

Southeast Asia, and Japan. Representatives of these geographic regions are meeting as the World Food Council. With the hypothetical help of Landsat imagery, have the Council develop some possible answers to the world food crisis.

8. **Related Sources of Information:**

NASA Films:

a. **The Wet Look** (KSC No. 624)
b. **Pollution Solution** (KSC No. 626)
c. **The Fractured Look** (KSC No. 627)
d. **Growing Concerns** (KSC No. 628)
e. **Land For People, Land For Bears** (KSC No. 629)
f. **Remote Possibilities** (KSC No. 630)
g. **ERTS-Earth Resources Technology Satellite** (KSC No. 554)

From the U.S. Government Printing Office, Washington, DC 20402:

a. NF-54, **The Spectrum,** S.60
b. NF-57, **Why Survey From Space,** S.45
c. 2401-2060, **Studying The Earth From Space** (Dept. of Interior), S.35
d. SP-360, **Mission to Earth; Landsat Views the World,** $14.00

Sources of Landsat Imagery:

Scenes imaged by Landsat 1 and 2 are available for purchase by the general public from:

a. User Services Unit
EROS Data Center
Sioux Falls, South Dakota 57198

b. National Cartographic Information Center
U.S. Geological Survey
507 National Center
Reston, Virginia 22092

c. U.S. Geological Survey
Branch of Distribution
1200 South Eads Street
Arlington, Virginia 22202

Remote Possibilities

Title: **Remote Possibilities**
Subject Area: Earth Science
KSC No. 630-color/sound 14:30 minutes
Level: junior high – high school

1. **Film Description:**

The responsible management of resources on Earth is of grave concern to all its inhabitants. The film presents Landsat and its "big picture from outer space". Through remote sensing, Landsat can provide telling visual imagery of our resource problems, in the fields of environmental quality, geology, water, land use, and agriculture. Multi-level sampling enables scientists to interpret the Landsat images and extrapolate to similar areas. The data acquired by the satellite are available to everyone to help resolve resource problems.

2. **Lesson Purpose:**

"Remote Possibilities" is designed to:

a. introduce the student to the Landsat satellite and its remote sensing capabilities as a valuable new tool in Earth resources management;
b. explain the technical processes of remote sensing;
c. survey some of the many applications of Landsat imagery;
d. explain that Landsat data are available and how they are pertinent to viewers.

3. **Objectives:**

After viewing the film the students will be able to:

a. define Landsat and explain what is meant by remote sensing.
b. list five existing resource management problems.
c. describe the type of imagery provided by Landsat and how these visuals are taken from space and made available on Earth.
d. define multi-level sampling and explain why it is needed to interpret Landsat images.
e. state the advantage of utilizing Landsat in making new maps and correcting existing maps.

4. **Vocabulary and Definitions:**

a. Landsat – A satellite that collects and relays global resource data by means of remote sensing.

b. Remote sensing – The means by which scanning instruments aboard Landsat detect and record the nature of objects on the Earth.

c. Spectral signature – The distinct arrangement of reflected visible and infrared light of any object, recorded in red, blue and green ranges.

d. Imagery – The "picture" that results from remote sensing.

e. Multi-spectral Scanner – The Landsat mirror mechanism that detects reflected light from Earth and directs it to the satellite's sensors.

f. Pixel – The ground area scanned by the Landsat sensor at tone time, measuring 1.1 acres.

g. Ground truth – Actual developments or conditions as observed on the ground in a specific area compared to Landsat imagery to check validity of photo-interpretation.

h. Cartography – The science of art of making maps.

i. Mosaic – A large image made by placing several smaller images together.

5. **Preparatory Activity:**

Choose an earth resource problem – perhaps one existing in your locality – and ask the class to solve it, using any method. Record all solutions and suggestions. Note any gaps in information needed to answer the problem. Is any solution satisfactory? Workable? Keep your observations for use in **Evaluation.**

6. **Follow-Up Activities:**

a. Light Dispersion – Send for the chart on "The Spectrum", NASA publication No. NF-54/1-75, (see related sources of information). Use it (or a similar chart) in conjunction with this simple experiment: Hold a prism in a narrow beam of sunlight or other parallel light source so that the beam coming from the prism is projected onto a white screen. Now do the same holding a piece of blue glass or plastic film in the path of the beam after it has passed through the prism. Repeat with red and green glass or plastic film. Record your observations, making comparisons and drawing conclusions.

b. A Simple Spectroscope – Obtain a diffraction grating replica in a cardboard ready-mount (available from scientific supply houses). Fit the ready-mount flush against the left edge of a shoebox front and about 1/2" above the bottom edge. Mark this position and remove the ready-mount. Cut a hole 1" square in the center of the marked position. Holding the grating to your eye, point it toward an electric light or the daytime sky (DO NOT LOOK DIRECTLY AT THE SUN), and turn the grating until it forms a horizontal *spectrum.* Keeping it in this position, glue the ready-mount to the box front at the place you marked earlier.

Turn the box around so that its rear faces you. At a distance of 1" from the left edge and about midway from top to bottom, carefully cut a narrow vertical slit about 3/4" long and 1/32" wide, using a razor blade. Edges of slit must be straight and clean. The slit should be diagonally opposite the grating.

Place the cover on the box. Hold the box with the grating close to your eye and the slit pointed as close as possible (about 6") to a light source. You should see a bright spectrum on the inside of the box end, straight ahead of you. You may paste a strip of white paper over this part of the cover to give you a better "screen," or you may use cross-section paper to provide a simple scale for comparison of different spectra. To make the scale visible, you will have to remove the cover from the box, or cut a narrow "window" in the back cover before pasting on the scale. Put consecutive numbers on the lines of the scale to help you compare different spectra.

Examine the spectra of daylight (DO NOT LOOK DIRECTLY AT THE SUN), fluorescent lighting, incandescent lighting, and glowing gas tubes (such as neon and sodium vapor). Record your observations and make comparisons.

c. Angles of Light – Using a single light source (one bulb), project light onto a relief map. Vary the angles – observe the differences. At which angle is the map best lit? Why would using other angles sometimes be desirable? (For example, geologists may want a more oblique angle to accent the relief.) Geologists also prefer that the Sun angle be the same in all images when making mosaics.

7. **Evaluation:**

Review the resource problem and proposed solutions discussed by the class as the **Preparatory Activity.** Have the students rethink their answers, using hypothetical data available through Landsat remote sensing. How does this supplemental information facilitate the problem-solving process?

8. **Related Sources of Information:**

NASA Films:

a. **The Wet Look** (KSC No. 624)

b. **Pollution Solution** (KSC No. 626)
c. **The Fractured Look** (KSC No. 627)
d. **Growing Concerns** (KSC No. 628)
e. **Land For People, Land For Bears** (KSC No. 629)
f. **Remote Possibilities** (KSC No. 630)
g. **ERTS-Earth Resources Technology Satellite** (KSC No. 554)

From the U.S. Government Printing Office, Washington, DC 20402:

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b. NF-57, **Why Survey From Space,** $.45
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Branch of Distribution
1200 South Eads Street
Arlington, Virginia 22202

Land for People, Land for Bears

Title: **Land For People, Land For Bears**
Subject Area: Earth Science
KSC No. 629-color/sound 14:30 minutes
Level: junior high – high school

1. **Film Description:**

Animals and people use the land – for shelter, food, transportation, to make their living. "Land For People, Land For Bears" looks at how Landsat supplies a new kind of data for land use mapping, change monitoring, and wildlife habitat mapping. Landsat's multi-spectral scanning instruments record the spectral signatures, or reflectance values, of the components of the Earth's surface. In Florida's Brevard and Orange counties, Landsat imagery is being used to monitor land development. Animal biologists are using Landsat imagery to identify habitats for the relocation of endangered animal species.

2. **Lesson Purpose:**

"Land For People, Land For Bears" is designed to:

a. acquaint viewers with the Landsat satellite and its remote sensing capabilities
b. show how Landsat imagery can assist in land use planning by offering regional views and interrelationships;
c. demonstrate that Landsat can provide comprehensive information on which people can base difficult land use choices;
d. stimulate viewers' interest in mapping, land use analysis and problem-solving using Landsat imagery.

3. **Objectives:**

After viewing the film the students will be able to:

a. list five important reasons it is necessary to plan the use of our land carefully.
b. describe how Landsat imagery is useful in monitoring land use changes in urban development.
c. discuss how Landsat imagery is helpful in wildlife habitat mapping.

4. **Vocabulary and Definitions:**

a. Landsat – A satellite that collects and relays global resource data by means of remote sensing.
b. Remote sensing – The means by which scanning instruments aboard Landsat detect and record the nature of objects on the Earth.
c. Spectral signature – The distinct arrangement of reflected visible and infrared light of any object, recorded in red, blue and green ranges.
d. Imagery – The "picture" that results from remote sensing.
e. Land use map – Map that documents categories of land use for a specific area, e.g., residential, commercial, transportation, agriculture, water, etc.
f. Change monitoring – The recording of changes in land uses in a sample area over a specific period of time.
g. Habitat – The place or type of site where a plant or animal naturally or normally grows and lives.
h. Vegetation – Plant life or total plant cover.

5. **Preparatory Activity:**

Contact your county conservation or urban development agency to obtain a conventional land use classification map of your

area. Become familiar with it – are there any patterns of development? Find out how the map was made: were a combination of techniques (aerial photography, land survey, etc.) used? When was it completed and published?

6. **Follow-Up Activities:**

   a. Ground Truth – Ground truth means to make observations on the ground and relate the features to those on a photograph or map. Obtain a highway map of your area, or use the land use map you obtained in the Preparatory Activity. Use the ground truth technique to check the map's accuracy. Note the differences and correct your map.

   b. Rainfall & Land Use – Obtain a color Landsat mosaic (lithographic copy) of an available state from the United States Geological Survey, Branch of Distribution, 1200 South Eads Street, Arlington, Virginia 22202. Locate major topographic and physiological areas – determine areas of population concentration, vegetation, etc. On an acetate overlay, chart rainfall distribution for the state. What inter-relationships can you determine? Can you discover possible reasons why rainfall is heavy in one area, scant in another?

   c. Wildlife Habitats – Has new development in your area displaced or removed natural wildlife habitats? Go to the developer of a recently completed project, or to one under construction, to discover what kinds of animals were living on the land before construction, and what the developer did to relocate them. How can concerned citizens in your areas make sure permanent destruction of wildlife habitats, without replacement, does not occur?

7. **Evaluation:**

   In your class, call a series of "town meetings" to discuss a proposed or theoretical land use project in your area. Divide the class into town citizens, town officials, and a non-partisan mediator. The mediator should define issues as they are discussed, encourage townspeople to form opinions based on personal experiences and research, etc. Follow the conventional means of developing an impact statement, but include hypothetical Landsat imagery. Allow class to explore ideas and new data, and project potential area growth, incorporating Landsat-based research. Resolve problem at final town meeting.

8. **Related Sources of Information:**

   NASA Films:

   a. **The Wet Look** (KSC No. 624)
   b. **Pollution Solution** (KSC No. 626)
   c. **The Fractured Look** (KSC No. 627)
   d. **Growing Concerns** (KSC No. 628)
   e. **Land For People, Land For Bears** (KSC No. 629)
   f. **Remote Possibilities** (KSC No. 630)
   g. **ERTS-Earth Resources Technology Satellite** (KSC No. 554)

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   c. U.S. Geological Survey
      Branch of Distribution
      1200 South Eads Street
      Arlington, Virginia 22202

Who's Out There?

Title: **Who's Out There?**
Subject Area: Mars Missions
KSC No. 587-color/sound 28 minutes
Level: junior high – high school

1. **Film Description:**

   This film utilizes the technique of dramatic narration coupled with film clips of Mars and an enthusiastic scientific symposium to explore the possibilities of life forms in our solar system, within our galaxy, or elsewhere in the universe.

   The narration is by Orson Welles whose flair for the dramatic creates interest and excitement in the presentation of the facts, theories, and conjectures that surround the concept of extraterrestrial life.

   The investigation of Mars by telescope has now been supplemented by television camera transmission from space probes that have flown past the planet. New information is accumulating, and it has been discovered that in many ways the surface features of Mars are more like those on Earth than those of the Earth's moon.

   Pictures of the Martian surface show the presence of the polar ice caps which grow and recede each year and the presence of craters, mountains, volcanoes, and sinuous, elongate, depressions which suggest the possibility of a fluid-caused erosion. Is it possible, then, that more water has been present on Mars than we have previously been willing to believe? Is it possible that rains, for thousands or millions of years, have produced some of this striking topography?

   The film suggests more questions than answers. Is life present? Has evolution – cosmic, chemical, biological – produced life forms similar to or different from our own? Will life be discovered on Mars or somewhere else within our solar system?

2. **Lesson Purpose:**

   This film is designed to:

   a. stimulate the viewer to consider that life forms may be found within our solar system.
   b. acquaint the viewer with the diverse environments in which life systems may thrive.
   c. illustrate the general topography of Mars.
   d. suggest the use of videocartologic methods for structuring topographic data.

3. **Lesson Alternatives:**

   a. Discuss how scientists gain data from space probes.
   b. Compare the concepts of the Martian landscape, as they evolved from data gained from telescopic observations, with the data gained from space probe camera transmissions.
   c. Build models of the Martian surface using papier-mache or plaster.
   d. Discuss pupil concepts of erosion.
   e. Compare aerial photographs of the Missouri-Mississippi River system with photographs of the Martian landscape. What similarities and differences are evident?

4. **Preparatory Activities:**

   a. Discuss the life processes of assimilation, communication, digestion, growth, ingestion, reproduction, response, sensitivity, transport.
   b. Compare the "life processes" of a virus with those of a bacterium. How are they similar? How are they unlike?
   c. Discuss the steps necessary for man to successfully colonize the Moon or Mars.
   d. Build a scaled model of the Sun and the planets Mercury, Venus, Earth, and Mars.
   e. Discuss the possibility that man evolved on a planet other than Earth. How might he have arrived here? Where might he have originated?
   f. Discuss the space probe explorations of the Viking and Mariner projects.
   g. Discuss the teamwork efforts needed to produce a successful space probe – the efforts of metallurgists, physicists, astronomers, chemists, biologists, machinists, technicians, administrators, cartographers.

5. **Objectives:**

   After viewing the film the students will:

   a. be able to list at least four of the following Martian features or conditions: (a) canyons, (b) "dried-up river beds," (c) dust storms, (d) craters, (e) "polar ice caps," (f) volcanoes.

b. better understand man's ability to hypothesize, theorize, guess at, conjecture, and dream about abstract concepts.
c. better understand man's ability to gather and interpret data in order to create or to solve problems.
d. be able to create mental images of the topography of Mars.
e. realize that individual scientists utilizing identical data may come to divergent conclusions.

6. **Vocabulary and Definitions:**

a. Impact craters – Surface craters created by the impact of solar system debris.
b. Life – The state or condition of an energy system which is capable of intraorganismic chemical synthesis and replication.
c. Mars – The fourth planet out from the Sun; planet most like Earth in the solar system.
d. Martian "dustorms" – Winds of 250-300 mph that generally last two to three days on the surface of Mars, moving large amounts of dust.
e. Polar caps – Polar bodies of water, ice, and frozen carbon dioxide that vary in size during the Martian year.
f. Solar system – The aggregates of matter that surround the Earth's nearest star, the Sun; most often described as the planetary system of Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto and such other discrete bodies as moons, planetoids, and fragments.
g. Space probe – A manned or unmanned vehicle used for penetrating space and capable of receiving and transmitting data.

7. **Presenting the Lesson:**

a. Use leading questions to stimulate student discussion.
b. Have a student write pertinent student questions on the chalkboard.
c. Briefly summarize preparatory discussions.
d. Show film in its entirety.
e. Discuss the film. Did it answer the questions?

8. **Follow-Up Activities:**

a. Have interested students prepare models of Mars, using clay, papier-mache, or other substances. Compare and contrast the surficial features of Mars to those of Earth.
b. Have students present position papers on their views of the possibility of life on Mars or elsewhere in the solar system/universe.
c. Provide opportunity for a formal debate of the positions developed in (b) above. Discuss the possible "evolution" of Mars and compare it to the evolution of the Earth.
d. Make a list of Earth organisms that might be able to survive the environmental conditions on Mars. Discuss the types of organisms that might be able to exist there from a knowledge of the terrain and environmental conditions present.

9. **Evaluation:**

Have pupils prepare a brief statement of the concepts that they have gained or modified. Prepare a test to evaluate the objectives and to measure pupil achievement.

10. **Related Sources of Information:**

NASA Films: See listing under Mars Missions.

From the U.S. Government Printing Office, Washington, DC 20402.

a. SP-334, **The Viking Mission to Mars,** $1.20
b. SP-337, **The New Mars,** $8.75
c. EP-50, **Space Resources for Teachers: Biology,** $3.25
d. EP-82, **Planetary Exploration,** $.95
e. EP-90, **Two Over Mars,** $.90
f. NF-76, **Viking Mission to Mars,** $.50

The Martian Investigators

Title: **The Martian Investigators**
Subject Areas: Mars Missions, Astronomy
KSC No. 499-color/sound 28 minutes
Level: high school

1. **Film Description:**

   This film attempts to show the human side of scientific investigators. Scientists, like other human beings, have diverse personalities that respond uniquely to the challenges, the successes, the failures, the accomplishments, the frustrations, the anxieties, the preconceptions, and the personal ego drives of the life process and the human spirit. The film shows the personal interactions of the scientists who were a part of the Mariner 6 and 7 fly-bys of Mars.

2. **Lesson Purpose:**

   The program can help pupils understand that scientists have the same human traits as other human beings and that the conflicts of personality and personal interest common to each of us can often be resolved by spirited discussion and eventual compromise.

3. **Lesson Alternatives:**

   a. Discuss how scientists might determine the presence or absence of chemical substances such as methane or carbon dioxide on Mars.

   b. Discuss the possible difference in appearance of volcanic craters and impact craters.

   c. Compare the surficial features of Mars with those of the Earth and the Earth's moon. What commonalities and differences exist?

4. **Preparatory Activities:**

   a. Discuss the kinds of education and training that Martian investigators might have in common.

   b. Discuss the specialized training that might be unique for each investigator.

   c. Discuss the similarities in appearance of solid carbon dioxide and water. How can one be distinguished from the other?

   d. Encourage pupils to identify unknown substances by spectrographic analysis. Discuss the use of infrared spectroscopy as a method for determining the presence or absence of chemical compounds.

5. **Presenting the Lesson:**

   a. Use leading questions to stimulate student discussion.

   b. Have a student write pertinent student questions on the chalkboard.

   c. Briefly summarize preparatory discussions.

   d. Show film in its entirety.

   e. Discuss the film. Did it answer the questions?

6. **Follow-Up Activities:**

   a. Discuss the environmental conditions needed for "life" as we know it.

b. Discuss what scientists might learn from an analysis of crater shapes, sizes, and locations.

c. Discuss the personality attributes that might help a person develop into a successful scientific investigator.

7. **Evaluation:**

Have pupils prepare a brief statement of the concepts that they have gained or modified. Prepare a test to evaluate the objectives and to measure pupil achievement.

8. **Related Sources of Information:**

NASA Films: See listing under Mars Missions.

From the U.S. Government Printing Office, Washington, DC 20402:

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b. SP-337, **The New Mars,** $8.75
c. EP-50, **Space Resources for Teachers: Biology,** $3.25
d. EP-82, **Planetary Exploration,** $.95
e. EP-87, **Space Resources for Teachers: Chemistry,** $2.95
f. EP-90, **Two Over Mars,** $.90
g. NF-76, **Viking Mission to Mars,** $.50

Shuttle Into Space

Title: **Shuttle Into Space**
Subject Area: Space Shuttle
KSC No. 657-color/sound 14:30 Minutes
Level: junior high – high school

1. **Film Description:**

Space can be widely used if it can be reached. This film follows the history of man's efforts to produce suitable spacecraft, beginning with the Chinese and their gunpowder. It includes Robert Goddard's embryonic rockets and those of modern day which powered man to the Moon. It delineates the components of the first of its kind, the reusable Space Shuttle.

2. **Lesson Purpose:**

"Shuttle Into Space" is designed to:

a. Provide an overview of the history of spacecraft.
b. Define the three main components of the Space Shuttle and their function.
c. Identify the advantages of the Space Shuttle as contrasted with other spacecraft.

3. **Objectives:**

After viewing the film the students will be able to:

a. Differentiate between the past launch vehicle and the Space Shuttle capabilities.
b. Identify several Space Shuttle uses.
c. Describe how the Space Shuttle works.
d. Name Space Shuttle major components.

4. **Vocabulary and Definitions:**

a. Artificial satellite – A man-made object that revolves about a spatial body, such as Explorer 1 orbiting about the Earth.

b. Booster – The part of a space vehicle which "boosts" the spacecraft to a desired position in space.

c. Capsule – A small, sealed, pressurized cabin with an internal environment which will support life. The term "spacecraft" is preferred to "capsule" for any man-carrying vehicle.

d. Getaway Special – An offer to individuals, industry and educational institutions to purchase space on the Space Shuttle to fly their own experiments.

e. Gyroscope – A device that spins and, by its motion, keeps a vehicle from changing its course.

f. Infrared radiation – Electromagnetic radiation lying in the wavelength interval from about 75 microns to an indefinite upper boundary sometimes arbitrarily set at 1000 microns.

g. NASA – The United States National Aeronautics and Space Administration established by Congress in 1958 to conduct research for the solution of problems of flight within and outside the Earth's atmosphere for peaceful purposes for the benefit of all mankind.

h. Orbit – The path of a body or particle under the influence of a gravitational or other force.

i. Oxidizer – Specifically, a substance (not necessarily containing oxygen) that supports the combustion of a fuel or propellant.

j. Payload – The portion of the space vehicle that will accomplish a particular mission in space; in rockets and

satellites, the data collection and transmitting equipment; in manned spacecraft, the personnel, life support systems, and equipment necessary to accomplish missions.

k. Space Shuttle – A versatile and reusable space flight system designed to provide ready access to Earth orbit.

l. Thrust – The forward propelling force in a jet or rocket engine developed as a recoil to the ejection of fuel gases at high velocities.

m. Transistor – A three-terminal semi-conductor device used for amplification, switching, and detection.

n. Vacuum tube – A device having an internal vacuum sufficiently high to permit electrons to move with low interaction with any remaining gas modules.

5. **Preparatory Activity:**

Bring into the classroom materials on rockets and spacecraft. These materials can take the form of newspaper clippings, pictures, models, recordings, etc. Ask your students to look for changes in rocket and spacecraft development over the years.

6. **Follow-up Activities:**

a. Prepare a bulletin board depicting a history of space travel. Obtain pictures of rockets and post on bulletin board.
b. Have students prepare a report on the physical and educational requirements and training of astronauts.
c. Develop a crossword puzzle or word search using the vocabulary found in the program or in this guide.
d. Ask your students to suggest other missions and payloads for the Shuttle.
e. Introduce model rockets. Discuss the characteristics of several types with emphasis on construction.

7. **Evaluation:**

Lead a class discussion in the following:

a. Becoming an astronaut is the dream of many people, children and adults. Why do you think people are attracted to space? (Adventure, curiosity, last frontier, etc.)
b. Do you think people can use space for practical purposes? How? (Satellites, communication, weather, Earth resources monitoring, solar power, telescopes, etc.)
c. What factors cause the high cost of sending people into space? (Rockets that can be used only once, the number of ground support people needed, the huge support facilities that must be maintained.)

8. **Related Sources of Information:**

NASA films:

a. **Live Via Satellite** (KSC No. 658)
b. **Doing Something About the Weather** (KSC No. 659)
c. **New View of Earth** (KSC No. 660)
d. **The Changing Universe** (KSC No. 661)
e. **Picture the Solar System** (KSC No. 662)
f. **Energy Alternatives** (KSC No. 663)
g. **Using Space Resources** (KSC No. 664)

Other Information: Public Services and Education Branch
Mail Code CA20
NASA Marshall Space Flight Center, AL
35812

Live Via Satellite

Title: **Live Via Satellite**
Subject Area: Communications
KSC No. 658-color/sound 14:30 minutes
Level: junior high – adults

1. **Film Description:**

"Live Via Satellite" is no longer extraordinary but an everyday occurrence. This film depicts the present use of satellite transmissions, e.g., telephone communication, television broadcasts, televised school classes, and medical consultations for remote areas. It also delineates some of the exciting future prospects for satellites placed in orbit by the Shuttle, including computer banking by satellite and the reproducing of whole libraries.

2. **Lesson Purpose:**

"Live Via Satellite" is designed to:

a. Acquaint the viewer with the basic design and function of present-day communications satellites.
b. Illustrate the problems accompanying the increasing number of satellites in orbit.
c. Elucidate the future uses of satellites in the era of the Space Shuttle.

3. **Objectives:**

After viewing the film, the students will be able to:

a. Describe the basic operation of a communications satellite.
b. Evaluate some of the advantages of using communications satellites rather than undersea cables for intercontinental communications.
c. Define the term "geostationary orbit."
d. Interpret the concept of bands of radio frequencies.

4. **Vocabulary and Definitions:**

a. Amplification – The process of increasing the magnitude of a variable quantity.

b. Band – A range of some physical variable, as of radiation wavelength or frequency.

c. Electromagnetic waves – Energy transmitted through space at the speed of light, whether visible or invisible.

d. Frequency – The rate at which wavelengths pass a given point in a second.

e. Geostationary orbit – A west-to-east orbit of the earth above the equator at an altitude of about 22,250 statute miles. At this altitude a satellite makes one revolution in 24 hours, synchronous with the Earth's rotation.

f. Ionosphere – An electrically conducting set of layers of the Earth's atmosphere, extending from altitudes of approximately 30 miles to more than 250 miles.

g. Microwaves – Any radio waves having a wavelength in the region between infrared and short-wave radio elements.

h. Transmission – The sending of modulated carrier waves from a transmitter.

5. **Preparatory Activity:**

Tell your students that this program is about communications by satellite. Ask them to look for ways in which communications satellites have aided various forms of communication. Discuss the various methods that have been used over the years to transmit information and ideas between individuals and between groups.

6. **Follow-up Activities:**

a. Visit a television or radio broadcasting facility.
b. Invite a local radio or television engineer to speak to the class.
c. Have students report on the history of communications satellites.

7. **Evaluation:**

The viewers should be able to answer these questions:

a. How do satellites enhance radio waves in receiving, amplifying and broadcasting signals?
b. What is "geostationary orbit" and why is it important?
c. What would be the advantage of a 30-meter antenna geostationary platform?

8. **Related Sources of Information:**

NASA films:

a. **Doing Something About the Weather** (KSC No. 659)
b. **New View of Earth** (KSC No. 660)
c. **The Changing Universe** (KSC No. 661)
d. **Picture the Solar System** (KSC No. 662)
e. **Energy Alternatives** (KSC No. 663)
f. **Using Space Resources** (KSC No. 664)

Other Information: Public Services and Education Branch
Mail Code CA20
NASA Marshall Space Flight Center, AL
35812

Doing Something About the Weather

Title: **Doing Something About the Weather**
Subject Area: Meteorology
KSC No. 659-color/sound 14:30 minutes
Level: junior high – high school

1. **Film Description:**

Weather does not just happen; it is caused. This film describes the three interrelated weather scales - microphysical (tiny particles), middle (front and cells); and global (layers of atmosphere). Earth's rotation as well as solar heat and wind also contribute to weather patterns. Experiments on all these areas will be carried out in zero gravity aboard the Shuttle and will be invaluable in improving our understanding of the complex phenomenon known as weather.

2. **Lesson Purpose:**

"Doing Something About the Weather" is designed to:

a. introduce the student to the three basic interrelated causes of weather.
b. illustrate some of the other associated causes of weather patterns.
c. survey briefly some of the experiments on weather conditions that will be conducted aboard the Space Shuttle.

3. Objectives:

After viewing "Doing Something About the Weather" the student will be able to:

a. name and describe three general areas of weather study.
b. particularize two weather experiments that will be carried on the Space Shuttle.
c. define the term magnetosphere.
d. enumerate some of the ways space can be used to learn more about the weather.

4. Vocabulary and Definitions:

a. Cold front – The leading portion of a cold atmospheric air mass moving against a warm air mass.

b. Condensation – The physical process by which a liquid is removed from a vapor or vapor mixture.

c. Evaporate – To change from a liquid to a gas, as from water to water vapor.

d. Magnetic field – A condition in a region of space, established by the presence of a detectable magnetic force at every point in the region.

e. Magnetosphere – A region around a planet in which the solar wind cannot penetrate because of its magnetic field.

f. Solar wind – The flow of electrons and protons streaming outward from the Sun throughout the solar system.

g. Supersaturate – To cause to be more highly concentrated than is normally possible under given conditions of temperatures and pressure.

h. Warm front – A front along which an advancing mass of warm air rises over a mass of cold air.

5. Preparatory Activities:

Tell your students that this program is about using space to better understand our weather. Ask your students to look for the advantages of conducting weather research in space.

6. **Follow-up Activities:**

a. Contact the National Weather Service for recent satellite images as well as surface weather maps. Compare the weather surface map with the satellite image for the same area and period of time.
b. Visit a National Weather Service station to gain firsthand knowledge of weather instruments and forecasting procedures.
c. To develop skills in compiling data, have students keep a record of daily weather procedures, including temperature, barometer reading, wind direction and visibility.
d. To encourage the use of reference materials, use periodical indexes and local newspapers to obtain information about the weather.

7. **Evaluation:**

The viewer should be able to:

a. Name and account for the three interrelated causes of weather.
b. List at least two weather experiments to be carried aboard the Shuttle.
c. Demonstrate some ways that space research can be helpful in learning more about the weather.

8. **Related Sources of Information:**

NASA films:

a. **Live Via Satellite** (KSC No. 665)
b. **New View of Earth** (KSC No. 660)
c. **The Changing Universe** (KSC No. 661)
d. **Picture the Solar System** (KSC No. 662)
e. **Energy Alternatives** (KSC No. 663)
f. **Using Space Resources** (KSC No. 664)

Other Information: Public Services and Educational Branch
Mail Code CA20
NASA Marshall Space Flight Center, AL
35812

New View of Earth

Title: **A New View of Earth**
Subject Area: Earth Sciences
KSC No. 660-color/sound 14:30 minutes
Level: junior high – high school

1. **Film Description:**

Satellites such as Landsat provide information otherwise inaccessible via remote sensors which, like unlike eyes, can detect bands of the electromagnetic spectrum. This film describes how the satellites'multi-spectral scanner detects light from each acre of earth in what is called a pixel. These pixels can be combined to create images of vast areas in order to detect polluting, forecast earthquakes, and predict crop yield, as well as to better regulate the use of land.

2. **Lesson Purpose:**

"A New View of Earth" is designed to:

a. Introduce the student to the Earth-resources satellite Landsat.
b. Demonstrate how Landsat creates color maps of various areas.
c. Delineate the advantages of such a satellite.

3. Objectives:

After viewing the film, students will be able to:

a. detail the operation of Landsat, an Earth resources monitoring satellite.
b. report on several ways in which Landsat images can be used to give us a clearer picture of the Earth.

4. Vocabulary:

a. Fault – A break in the continuity of a rock formation, caused by shifting or dislodging of the Earth's crust.

b. Geology – The scientific study of the origin, history, and structure of the Earth.

c. Pixel – A measurement of light reflected from 1.1 acres of land to a remote sensor on Landsat.

d. Remote sensor – In the broadest sense, the measurement, or acquisition of information, of some property of an object phenomenon under study.

5. Preparatory Activities:

Tell your students that this program will show how Landsat satellites gather and transmit data about the Earth, and how this data is stored, retrieved and used by mankind. Ask your students to be ready to name several ways Landsat images are used by man to study the Earth.

6. Follow-up Activities:

a. Contact county conservation and urban development offices for information which will help students make a regional map showing possible sources of pollution, types and extent.
b. Divide the class into ten major world areas: North America, South America, Europe, USSR, Middle East, Africa, China, India, Asia and Japan. Representatives of these regions are meeting on the World Food Council. With the hypothetical help of Landsat imagery, have the council develop some possible answers to the world food crisis.
c. Lead your students in a discussion of the importance of land-use management.
d. Discuss the number of Earth-resources investigations that are possible by using remotely sensed information. (Map making geology, water resources, oceanography, meteorology, geography, ecology.)

7. **Evaluation:**

After viewing this film, students should be able to:

a. Particularize the operations of Landsat.
b. Evaluate the major uses of Landsat data.

8. **Related Sources of Information:**

NASA films:

a. **Live Via Satellite** (KSC No. 665)
b. **Doing Something About the Weather** (KSC No. 659)
c. **The Changing Universe** (KSC No. 661)
d. **Picture the Solar System** (KSC No. 662)
e. **Energy Alternatives** (KSC No. 663)
f. **Using Space Resources** (KSC No. 664)

Other Information: Public Services and Educational Branch
Mail Code CA20
NASA Marshall Space Flight Center, AL
35812

U. S. Geological Survey
1200 South Eads Street
Arlington, Virginia 22202

The Changing Universe

Title: **The Changing Universe**
Subject Areas: Astronomy
KSC No. 661 color/sound 14:30 minutes
Level: junior high – high school

1. **Film Description:**

Although scientists have studied the stars for centuries, satellites such as the High Energy Astronomy Observatories offer the first real opportunity to observe them. This film delineates the knowledge we have gained about our closest star, the Sun, its life cycle and tremendous impact on our climate. From deep-space studies, we can more readily contemplate phenomena such as X-rays and gamma radiation, in order to better understand our universe.

2. **Lesson Purpose:**

"The Changing Universe" is designed to:

a. acquaint the students with our closest star, the Sun.
b. depict, in detail, the life cycle of stars.
c. heighten awareness of the many phenomena in space made more accessible with the advent of satellite observatories.

3. **Objectives:**

After viewing "The Changing Universe" the student will be able to:

a. name and characterize the four main regions of the Sun.
b. elucidate the life cycle of stars.
c. name several satellites that are being used to study the universe.

4. **Vocabulary and Definitions:**

a. Astronomy – The science of the celestial bodies and of their magnitudes, motions, and constitution.

b. Black hole – The final stage in the collapse of a massive dying star. The collapsed star's material is so densely packed and the gravitational force so great that even light waves are unable to escape from its surface.

c. Chromosphere – A transparent gaseous layer, primarily hydrogen, several thousand miles in depth, that lies above and surrounds the photosphere or surface of the Sun.

d. Core – The center of the Sun's energy.

e. Corona – The luminous irregular outer envelope of highly ionized gas where the highest temperatures occur as the result of shock waves sent upward from the surface of the Sun.

f. Galaxy – One of billions of systems each including stars, nebulae, star clusters, globular clusters, and interstellar matter that makes up the universe.

g. Photosphere – The surface of the Sun, and source of most of its heat and light.

h. Pulsar – Discovered in 1967, pulsars emit radio signals whose pulsations are extremely precise. The evidence suggests that pulsars derive from the axial tilt of fast-spinning neutron stars.

i. Radio telescope – A sensitive, directional radio-antenna system used to detect and analyze radio waves of extraterrestrial origin.

j. Stellar – Of or relating to stars.

k. Supernova — A large star at life's end, whose final collapse is a cataclysmic event that generates a violent explosion, blowing the remains of the star out into space.

6. **Follow-up Activities:**

a. Report on the most recent solar eclipse (February 26, 1979). If a small telescope is available, use it to project the Sun's image on a white sheet of poster paper. Observe the Sun daily at the same hour to denote its rotation.
b. Assign mini-reports on various subjects, instruments, and personalities covered in this program.
c. Locate star constellations one evening.
d. Discuss the importance of continued space exploration of the universe.

7. **Evaluation:**

a. Name and differentiate the four regions of the Sun.
b. Characterize the stages of the life cycle of a star.
c. Particularize the kinds of images better seen by satellites such as the High Energy Astronomy Observatory.

8. **Related Sources of Information:**

NASA films:

a. **Live Via Satellite** (KSC No. 665)
b. **Doing Something About the Weather** (KSC No. 659)
c. **New View of Earth** (KSC No. 660)
d. **Picture the Solar System** (KSC No. 662)
e. **Energy Alternatives** (KSC No. 663)
f. **Using Space Resources** (KSC No. 664)

Other Information: Public Services and Educational Branch
Mail Code CA20
NASA Marshall Space Flight Center, AL
35812

Picture the Solar System

Title: **Picture the Solar System**
Subject Areas: Astronomy
KSC No. 662-color/sound 14:30 minutes
Level: junior high – high school

1. **Film Description:**

Although Copernicus and Galileo's original depictions of the solar system were quite accurate, many intriguing discoveries awaited the scientific satellites of the space age. Because of these, we are able to closely study Mercury, Venus, Earth, Mars, the asteroids, Jupiter, Saturn, Uranus, Neptune, and Pluto, as well as the comets which orbit the Sun. Theories about how the solar system evolved are being challenged by the data from Voyager and Pioneer Venus probes.

2. **Lesson Purpose:**

"Picture the Solar System" is designed to:

a. introduce the students to the basic design of the solar system.
b. interpret some of the theories of its evolution.
c. indicate the advantages of Space Shuttle-launched probes.

3. **Objectives:**

After viewing the film the student will be able to:

a. recount a brief history of the study of the solar system.
b. portray the solar system in general and several of the planets in detail.
c. name several planetary probes designed to study the solar system.
d. demonstrate how studying the other planets can help us better understand our own planet.

4. **Vocabulary and Definitions:**

a. Asteroid belt – The collection of numerous celestial bodies with characteristic diameters between one and several hundred miles and orbits lying chiefly between Mars and Jupiter.

b. Orbit – The path of a celestial body or man-made satellite as it revolves around another body.

c. Spectrogram – A photograph or diagram of a spectrum.

5. **Preparatory Activities:**

Tell your students that this program presents a brief history of the study of our solar system. Give your students an overview of the major bodies in the solar system and ask them to look for some of the ways in which we have "pictured" our solar system.

6. **Follow-up Activities:**

a. Assign outside reading or projects on the most recent findings concerning our solar system as a result of U.S. space missions.
b. Make a model of the Sun and planets in our solar system using coat hangers and styrofoam balls, clay, papier-mache or similar materials.
c. Using a long string and a scale of one million miles to an inch, position the planets at their proper distance from the Sun to illustrate the vast intervals between the outer planets.
d. Have students present position papers on their views of the possibility of life elsewhere in the solar system/universe.

7. **Evaluation:**

Prepare and give a test on the solar system, in general, requiring descriptions of several of the planets in detail, as well as some of the planetary probes studying the planets.

8. **Related Sources of Information:**

NASA films:

a. **Live Via Satellite** (KSC No. 665)
b. **Doing Something About the Weather** (KSC No. 659)
c. **New View of Earth** (KSC No. 660)
d. **The Changing Universe** (KSC No. 661)
e. **Energy Alternatives** (KSC No. 663)
f. **Using Space Resources** (KSC No. 664)

Other Information: Public Services and Education Branch
Mail Code CA20
NASA Marshall Space Flight Center, AL
35812

Energy Alternatives

Title: **Energy Alternatives**
Subject Areas: Technology Utilization
KSC No. 663-color/sound 14:30 minutes
Level: junior high – high school

1. **Film Description:**

We do not create energy; we take it from nature. Since fossil fuels such as oil and gas are in short supply, alternative forms of energy are essential. Solar collectors and cells, windmills, geothermal and nuclear energy are among the viable and effective producers of energy.

2. **Lesson Purpose:**

"Energy: Alternatives" is designed to:

a. present the need to find alternative energy sources.
b. particularize some of the research being done on various kinds of energy.

3. **Objectives:**

After viewing "Energy: Alternatives" the student will be able to:

a. recount several methods of taking energy from nature.
b. demonstrate several ways of converting the energy taken from nature into useful forms.
c. define the term "energy".

4. **Vocabulary and Definitions:**

a. Nuclear fusion – The union of atomic nuclei to form heavier nuclei resulting in the release of enormous amounts of energy.

b. Geothermal – Of or relating to the heat of the Earth's interior.

c. Photovoltaic – Of, relating to, or using the generation of an electromotive force when radiant energy falls on the boundary between dissimilar substances.

d. Turbine – A rotary engine actuated by the reaction or impulse, or both, of a current of fluid subject to pressure and usually made with a series of curved vanes on a central rotating spindle.

5. **Preparatory Activities:**

Tell your students that this program presents some possible alternative energy sources and alternative ways to convert it for use. Energy conservation is stressed. Request your students to be able to describe various methods of taking energy from nature and converting the energy to useful forms.

6. **Follow-up Activities:**

a. Make an "energy use" study of your school. Identify where energy is used and how much. Develop ways to conserve energy.
b. Investigate one form of energy, its long-term strengths and weaknessess, and its effect on the local community, state and nation.
c. Explore and report on probable consequences of a long-term fuel shortage on these areas and industries: food, clothing and textiles, cosmetics, plastics, household supplies, transportation, retailing, fast-food operations and autos.
d. Create a one-minute radio or television commercial dealing with some aspect of energy conservation.
e. Estimate the minimum amount of energy you would need for bare existence for one week.

7. **Evaluation:**

   a. Define "energy".
   b. Report on alternative sources of energy.
   c. Evaluate other energy sources as compared to fossil fuels.

8. **Related Sources of Information:**

   NASA films:

   a. **Live Via Satellite** KSC No. 655)
   b. **Doing Something About the Weather** (KSC No. 659)
   c. **New View of Earth** (KSC No. 660)
   d. **The Changing Universe** (KSC No. 661)
   e. **Picture the Solar System** (KSC No. 662)
   f. **Using Space Resources** (KSC NO. 664)

   Other Information: Public Services and Education Branch
   Mail Code CA20
   NASA Marshall Space Flight Center
   35812

Using Space Resources

Title: Using Space Resources
Subject Areas: Technology Utilization
KSC No. 664-color/sound 14:30 minutes
Level: junior high – high school

1. Film Description:

There are intriguing feature projects made possible by the Space Shuttle. These include: Spacelab, in which manufacturing and processing will be a reality; a 25-kilowatt power system to provide the Shuttle with renewed power in space; a separate propulsion system utilizing solar energy and mercury to reposition loads, as well as a tethered satellite (for weather observations) among others.

2. Lesson Purpose:

"Using Space Resources" is designed to:

a. delineate the many future uses of space.
b. particularize some of the proposed projects in conjunction with the Space Shuttle.
c. specify the potential benefits for mankind in utilizing space as a resource.

3. Objectives:

After viewing "Using Space Resources" the student will be able to:

a. evaluate the potential of learning to use space for the benefit of all mankind.
b. name and describe several research projects designed for Spacelab, and international laboratory in space.
c. specify several ways in which space can be used as a natural resource.

4. Vocabulary and Definitions:

a. Solar wind – A stream of electrons and protons constantly moving outward from the Sun.

b. Teleoperator Retrieval System – An orbital servicing system which could extend the capabilities of the Shuttle. It could perform satellite services by remote control at long distances from the Shuttle.

5. Preparatory Activities:

Explain that this film specifies many possible future uses for space and detail how using space has potential benefits for mankind. Ask them to watch for the many fields of research that are considered, and the conditions in space which provide a unique environment for research and experimentation.

6. Follow-up Activities:

a. Assign outside reading projects on the ways in which the processing of materials in space can be done.
b. Establish a library of recent space-related publications and periodically review them for class discussion.
c. Direct a discussion of the various aerospace careers and the potential for new career fields related to space science and technology.
d. Analyze the meaning of space as a resource for Earth.

7. Evaluation:

a. Name and describe several projects designed for Spacelab and associated with the Shuttle.
b. Analyze the potential of access to space as a resource, as provided by a reusable Shuttle.

8. Related Sources of Information:

NASA films:

a. **Live Via Satellite** (KSC NO. 665)
b. **Doing Something About the Weather** (KSC No. 659)
c. **New View of Earth** (KSC No. 660)
d. **The Changing Universe** (KSC No. 661)
e. **Picture the Solar System** KSC No. 662)
f. **Energy Alternatives** (KSC NO. 663)

Other Information: Public Services and Education Branch
Mail Code CA20
NASA Marshall Space Flight Center, AL
35812

Your Home and Environment

Title: **Space Research and You . . . Your Home and Environment**
Subject Area: Comparative planetology, remote sensing, pollution, energy
KSC No. 672, Color/Sound 15 Minutes
Level: 7-12th grades

1. **Film Description:**
"Space Research and You. . . Your Home and Environment" illustrates some ways in which NASA space research helps to enhance the quality of life on Earth. By sending spacecraft to other planets new insights are gained into the complex processes that have formed and continue to modify our Earth. Study of our Earth has been furthered by orbiting satellites such as the Landsat system. Using sensors that break reflected light into component colors, Landsat is able to map the Earth's surface, record changes, detect pollution, monitor crop growth, and search for new minerals and energy resources. On the Earth, a new system for sewage treatment that relies on the filtering capabilities of the water hyacinth has been devised by NASA scientists. These prolific plants thrive in tanks that are fed polluted water. Following the filtering of the water by the plants, the plants, now engorged with pollution, are harvested and turned into garden mulch or are converted into methane gas for cooking and other uses. Technology for heat control and electric power generation in orbiting spacecraft has been adapted for use in homes. In a specially constructed demonstration house, solar thermal collectors for space heating, solar cells, and a variety of energy-saving devices have been incorporated for scientific evaluation of their effectiveness. NASA research with airplane wing sections and propeller designs is being applied to improving a very old device, the windmill. In cooperative research with other agencies, NASA scientists have developed giant wind turbines that are generating power for several test communities around the nation. NASA research in aeronautics and space is producing benefits far beyond its original scope.

2. **Lesson Purpose:**
"Space Research and You. . .Your Home and Environment" is designed to:
   a. acquaint viewers with ways NASA aeronautical and space research impacts their home and environment;
   b. illustrate that scientific study of other planets and the Earth from space helps us to better understand our planet and protect its resources;
   c. illustrate potential alternative energy sources for meeting our energy needs;
   d. demonstrate a variety of energy-saving technologies for home use;
   e. demonstrate a new sewage treatment facility developed by NASA researchers.

3. **Objectives:**
After viewing the film, the students will be able to:
   a. discuss how planetary research helps us to better understand our Earth and protect it;
   b. explain what remote sensing is and how it can monitor Earth resources;
   c. identify several examples of how aerospace research has led to new devices and technology for home use;
   d. explain the water hyacinth sewage treatment process;
   e. discuss the operation and energy potential of wind turbines.

4. **Vocabulary and Definitions:**
   a. Comparative planetology – The scientific study and comparison of the planets in our solar system. From this study, hints about the origin and future of the Earth are derived.
   b. Landsat – A satellite system (formerly called ERTS) designed to study the landmass of the Earth and monitor its resources.
   c. Remote sensing – (Applied to satellites and space probes) Scientific study of a planet or other celestial object from a distance with data gathered by cameras and electronic instruments.
   d. Thermograph – A special kind of remote sensing technique in which thermal radiations from an object are displayed as a color image. On a thermograph, areas radiating the greatest heat are portrayed with bright colors and areas of cooler radiation with dark colors.
   e. Water Hyacinth – A vascular acquatic plant that through prolific growth quickly clogs lakes and waterways in the southeastern United States.

5. **Preparatory Activities:**
   a. Collect and display planetary pictures that show surface features, such as volcanoes and canyons similar to those found on earth.
   b. If water hyacinths thrive in the area where you live, collect samples for displays and experiments.
   c. Have some students research the history of windmills and wind turbines.
   d. Have some students collect samples of modern household technologies from home magazines.
   e. Obtain Landsat images of the area where you live. (Refer to the back of this lesson guide for ordering information.)

6. **Follow-up Activities:**
   a. If you live in an area where hyacinths thrive, experiment with the water filtering properties of these plants by placing them in acquariums containing polluted water.
   b. Experiment with using water hyacinths as a mulch for garden plants. Be sure to use a commercial mulch on similar plants as an experimental control.
   c. Study Landsat images of the area where you live. Try to identify geographic features, water, mineral, and agricultural resources. Look for signs of pollution.
   d. Build a miniature wind turbine test stand. Mount a toy DC motor horizontally to the top of a small tower. Adapt the motor shaft to receive various blade designs. Run the wires from the motor to a milliammeter. Protect the milliammeter from too much current by wiring resistors in series into the circuit. Direct the exhaust of a window fan at the blades. Measure the current output of the motor, now turned generator, with the milliammeter. Vary the pitch of the blades and again measure the output. Have students design and construct different blade shapes for the test stand.
   e. Experiment with solar heat collectors and solar cells.

7. **Evaluation:**
   The students should be able to answer the following questions after the lesson:
   a. Why is the study of planets important for understanding Earth?
   b. In general terms, how does Landsat operate?
   c. What can be learned about the Earth by studying it from outer space?
   d. How does the water hyacinth sewage treatment process work?
   e. How is aerospace research affecting the design of windmills?

8. **Related Sources of Information:**
   NASA Films:

   HQ319, **"Space Research and You. . . Your Health"**
   HQ 320, **"Space Research and You. . . Your Transportation"**

   NASA Publications available from the U.S. Government Printing Office, Washington, DC 20402

   a. **Spinoff 1981,** $6.50 (033-000-00826-1)
   b. **Spinoff 1980,** $5.50 (033-000-00789-2)
   c. **Spinoff 1979,** $4.25 (033-000-00757-4)
   d. **Landsat: A Tool for your Classroom,** $1.00 (033-000-00746-9)
   e. NF-80, **Landsat Wallsheet,** $1.50 (033-000-00702-7)
   f. EP-149, **NASA Tech House,** $1.50 (033-000-00704-3)
   g. SP-360, **Mission to Earth: Landsat Views the World,** $14.00 (033-000-00659-4)
   h. SP-442, **Lesson from the NASA Tech House,** $3.00 (033-000-00792-2)

   Landsat Pictures

   EROS Data Center
   U.S. Geological Survey
   Sioux Falls, SD 57198
   (Write for ordering details and price list.)

Your Transportation

Title: Space Research and You. . .Your Transportation
Subject Area: Transportation, energy, safety
KSC No. 673, Color/Sound 15 Minutes
Level: 7-12th grades

1. **Film Description:**
"Space Research and You. . .Your Transportation" examines how NASA research has led to improvements in land, sea, air, and space travel. New technologies for greater safety, convenience, speed, and energy efficiency are explored. For land transportation, research on electric automobiles is examined as an energy alternative to internal combustion engine powered vehicles. Energy-saving streamlining effects of wind deflectors for trucks are demonstrated with the use of smoke generators. In marine transportation, a computer simulation facility, adapted from lunar astronaut training programs, is used to train ship crews. With the simulator, crews can practice responses to an unlimited variety of emergency situations that might arise while navigating the world waterways, without endangering actual ships or crews. Turbopumps, modified from the Saturn V Moon launch vehicle, are shown propelling hydrofoil boats. Air transportation improvements feature a new vertical takeoff and landing plane that combines the convenience of a helicopter with the efficiency and speed of conventional planes. A new wingtip design, being incorporated into production models of business jets, reduces air drag and promotes energy savings. Advanced energy-saving propeller and jet engine designs are also presented and new, lightweight composite materials that reduce the weight of aircraft, resulting in additional energy savings, is shown. Advances in launching satellites, space probes, and construction materials into space are illustrated with the launch and landing of NASA's Space Shuttle. NASA research in aeronautics and space is helping to make the ways we travel safer, more efficient, and convenient.

2. **Lesson Purpose:**
"Space Research and You. . .Your Transportation" is designed to:
   a. acquaint viewers with ways NASA aeronautics and space research impacts their lives in the field of transportation;
   b. illustrate the need to apply energy-saving technologies to various modes of transportation;
   c. demonstrate that research with no apparent immediate benefit often leads to practical applications.

3. **Lesson Objectives:**
After viewing the film, the students will be able to:
   a. identify several examples of technology transfer from aeronautics and space research to the field of transportation;
   b. discuss the need for energy-saving technology in transportation;
   c. explain the use of computer simulators in ship crew training;
   d. explain why weight reduction in aircraft and streamlining of vehicles saves energy.

4. **Vocabulary and Definitions:**
   a. CAORF – Computer Aided Operations Facility.
   b. Composite material – Two or more materials joined together to improve structural properties. An example of a composite material is graphite epoxy; graphite fibers surrounded by a matrix of epoxy cement.
   c. Computer simulator – A computer-driven device that simulates the controls of a vehicle and permits an operator to practice controlling the vehicle under a variety of realistic situations.
   d. Hydrofoil – A vessel equipped with wing-like surfaces beneath the hull that raises the vessel out of the water when traveling at high velocities.
   e. Streamlining – Shaping the exterior of a vehicle that is intended for operation in air or water so that the air or water flows around and past the vehicle in smooth lines.
   f. VTOL – Vertical Takeoff and Landing.

5. **Preparatory Activities:**
   a. Collect pictures and reading material on the Space Shuttle and display them for the students.
   b. Research the history and current status of vertical takeoff and landing aircraft.
   c. Have some students study the use of computer simulators for training aircraft and ship crews.
   d. Collect and display materials on electric-powered vehicles.

6. **Follow-up Activities:**
   a. Have some students research the cost of fuel, equipment, maintenance, and personnel for a commercial airline that serves the region where you live. Plot cost information on a graph. Compare costs today with costs 10 to 20 years ago.
   b. Experiment with the aerodynamic shapes of model trucks by the use of a small wind tunnel. A wind tunnel can be made from a long cardboard box. Cut out a large window from one side and replace it with clear plastic. Paint the opposite inside wall dull black. In the upwind opening of the tunnel mount vertical dividers to smooth the airflow through the tunnel. Using a window fan, direct air into the tunnel and across the model truck. Have your students design a smoke generator and place it in front of the truck to mark the air flow. Challenge students to develop structures for the model that will smooth the air flow.
   c. Have the students design potential payloads for the Space Shuttle and future space stations.
   d. Invite some students to design and build electric powered model automobiles.
   e. If your school has television equipment, construct a small version of a CAORF simulator. Prepare a small set showing a waterway with a harbor, bridges, ships, and shore structures to scale. The set should be constructed out of sturdy materials that can be suspended in an inverted position. The set must be just high enough to allow the television camera, mounted on a wheeled tripod, to slide freely underneath. Run cables from the camera to a television monitor in another location. Because the set is upside down, the camera should be inverted on the tripod in order to "right" the picture on the monitor. Choose one student to captain the ship and give commands to the ship's crew (students moving the tripod and camera) on the basis of the scene on the monitor. The captain's task is to safely direct the ship's movements through the set on a preplanned course.

7. **Evaluation:**
   The students should be able to answer the following questions after the lesson:
   a. Why is energy efficiency an important consideration in the design of future transportation?
   b. How is the VTOL shown in the movie different from helicopters and conventional aircraft?
   c. What potential benefits might the Space Shuttle produce?
   d. How does the CAORF simulator promote shipping safety?
   e. Why is it important to develop electric automobiles?
   f. What energy-saving feature has been developed through NASA research for trucks?
   g. What are several ways energy efficiency is being designed into new aircraft?

8. **Related Sources of Information:**
   NASA Films:

   HQ 319, **"Space Research and You. . . Your Health"**
   HQ 321, **"Space Research and You. . . Your Home and Environment"**

   NASA publications available from the U.S. Government Printing Office, Washington, DC 20402

   a. **Spinoff 1981,** $6.50 (033-000-00826-1)
   b. **Spinoff 1980,** $5.50 (033-000-00789-2)
   c. **Spinoff 1979,** $4.25 (033-000-00757-4)
   d. EP-85, **NASA Aeronautics,** $2.00 (033-000-00796-5)
   e. EP-156, **Space Shuttle at Work,** $3.75 (033-000-00779-5)
   f. EP-169, **Aboard the Space Shuttle,** $2.50 (033-000-00806-6)
   g. NF-81, **Space Shuttle Wallsheet,** $2.50 (033-000-00743-4)
   h. NF-96, **Aircraft Energy Efficiency Overview,** $1.50 (033-000-00812-1)

Your Health

Title: Space Research and You. . . Your Health
Subject Area: Medical technology, health care
KSC No. 674, Color/Sound 15 Minutes
Level: 7-12th grades

1. **Film Description:**
"Space Research and You. . . Your Health" depicts a variety of medical advances made possible because of technology developed for the United States' space program. Developed from miniaturizing spacecraft components comes a programmable pacemaker that helps heart patients. Without resorting to surgery, a doctor can "fine-tune" or reprogram as many as six heart-stimulating functions in this new pacemaker. Also a result of spacecraft miniaturization, a Programmable Implantable Medication System (PIMS) monitors the sugar level in the blood of a diabetic patient and through a sophisticated hydraulic system, dispenses medication from a reservoir within the device. The PIMS system could become a powerful tool in the treatment of diabetes and other diseases. Camera systems from the Viking lander spacecraft have been adapted into an optical profilometer that assists in monitoring the effectiveness of corrective surgery for children afflicted with cleft palates. The device scans casts made of the patient's mouth and develops a reference bank of information to guide future corrective operations. Image processing techniques for pictures transmitted by the Voyager spacecraft are being used to diagnose heart disease, especially arteriosclerosis. With the use of a computer, the image processing technique helps measure the extent of blockage in arteries. Transplants of synthetic bone joints are more likely to be successful through the use of a microscopic sand-blasting technique using a discharge of ions from an ion thruster rocket engine. The ions from the engine texture the implant to closely approximate natural bone surface and promote body tissue acceptance. Maintaining astronaut health while in orbiting spacecraft required that medical data be transmitted to doctors on Earth. A similar system is being used for rural health care on the Papago Indian Reservation in Arizona. While patients are being examined by a health care specialist, a doctor many kilometers away watches the examination on a television monitor and prescribes treatment. From Earth-orbiting satellites and space probes penetrating our solar system to manned space stations, new medical technology is emerging that can benefit all people.

2. **Lesson Purpose:**
"Space Research and You. . . Your Health" is designed to:

   a. acquaint viewers with ways NASA space research impacts their daily lives;
   b. demonstrate that research with no apparent immediate benefit often leads to practical applications.

3. **Objectives:**
after viewing the film, the students will be able to:

   a. identify several examples of technology transfer from space research to the health and medical field;
   b. explain why miniaturization is important to medical technology
   c. describe, in general terms, the nature of medical problems pictured in the film including diabetes, arteriosclerosis, and clef palate.

4. **Vocabulary and Definitions:**

a.	Arteriosclerosis	–	A disease of the arteries that is characterized by a hardening and thickening of the walls, causing a reduced blood flow. The disease especially afflects elderly people.
b.	Cleft Palate	–	A birth defect consisting of a longitudinal fissure in the roof of the mouth.
c.	Coronary angiogram	–	An x-ray photograph of the coronary arteries following an intervascular injection of a substance that is opaque to x-rays.
d.	Diabetes	–	A disease that impairs the body's ability to use sugar.
e.	Ion Thruster	–	An electrically powered rocket engine that produces thrust by accelerating ions through a magnetic grid.
f.	Pacemaker	–	An implantable device that regulates heartbeats through rhythmic electrical pulses.
g.	PIMS	–	Programmable Implantable Medication System.
h.	STARPAHC	–	Space Technology Applied to Rural Papago Health Care.

5. **Preparatory Activities:**

   a. Assign students to research and report on the diseases of arteriosclerosis and diabetes.
   b. Collect and display pictures of Mars, Jupiter, and Saturn that were returned by the Viking and Voyager missions.
   c. Assign students to research and report on the effects miniaturization of electronic components has had on our daily lives.

6. **Follow-Up Activities:**

   a. Produce a simple sketch of a coronary artery that is partially blocked due to the build-up of plaque. Have students estimate the extent of the blockage. Record and average the range of student estimates. Transfer the sketch to graph paper and, by counting squares, carefully determine the extent of blockage. Compare student estimates to the measured values. Note: Before the use of the image processing technique illustrated in the movie, doctors had to estimate the extent of artery blockage.
   b. Have some students learn about medical communication techniques used in their own community.
   c. Research other medical advances that have resulted from space technology developments.
   d. Research the use of ion thruster engines for spacecraft propulsion.

7. **Evaluation:**

   The student should be able to answer the following questions after the lesson:

   a. What are the following medical conditions: arteriosclerosis, cleft palate, and diabetes?
   b. How have spacecraft imaging systems helped the treatment of arteriosclerosis and cleft palate?
   c. Why is the STARPAHC system used for the Papago Indians important?
   d. What does the PIMS do?
   e. How does a programmable pacemaker help heart patients and their doctors?
   f. How is an ion thruster rocket engine used in making bone joint implants?

8. **Related Sources of Information:**

   NASA Films:

   HQ 320, **"Space Research and You. . . Your Transportation"**

   HQ 321, **"Space Research and You. . . Your Home and Environment"**

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   c. **Spinoff 1979,** $4.25 (033-000-00757-4)
   d. EP-146, **Mars—The Viking Discoveries,** $1.50 (033-000-00703-5)
   e. SP-368, **Biomedical Results of Apollo,** $13.50 (033-000-00628-4)
   f. SP-377, **Biomedical Results from Skylab,** $10.50 (033-000-00648-9)
   g. **Voyager Encounters Jupiter,** $3.00 (033-000-00772-8)
   h. **Voyager 1 Encounters Saturn,** $2.75 (033-000-00817-1)

Alphabetical Index

Title	KSC No.	Page
A		
A is for Aeronautics	332	13
Adventures in Research	606	14
Age of Space Transportation	621	7
All Systems Go	274	1
America in Space	149	1
America in Space: The First Decade	441	1
America's Wings	625	13
Anatomy of an Accident: It Can't Happen to Me	509	16
Apollo/Soyuz Test Project	572	2
Apollo 4 Mission	428	4
Apollo 9: The Space Duet of Spider and Gumdrop	457	4
Apollo 10: Green Light for a Lunar Landing	486	4
Apollo 11: Launch Mission Report	491	4
Apollo 12: Pinpoint for Science	497	5
Apollo 13: Houston, We've Got a Problem	504	5
Apollo 14: Mission to Fra Mauro	513	5
Apollo 15: In the Mountains of the Moon	527	5
Apollo 16: Destination Descartes	542	5
Apollo 16: Nothing so Hidden	541	5
Apollo 17: On the Shoulders of Giants	553	5
Art of Soft Soldering	66	16
Assignment: Shoot the Moon	409	6
Astronaut Training	481	6
Automobile Tire Hydroplaning–What Happens	381	15
B		
Before Saturn	120	1
Big Challenge	378	3
Blue Planet	544	2
C		
Canaveral to Kennedy	469	5
Case for Regeneration	310	13
Celestial Mechanics and the Lunar Probe	121	10
Ceramics in Space	419	16
Challenge of Unanswered Questions	427	16
Changing Universe*	661	11
Chemistry of Life	79	14
Clouds of Venus	124	10
Computer for Apollo	364	14
Conservation Laws in Zero G*	589	6
Control and Rescue in Hypergolic Fires	675	16
Countdown to Rendezvous	312	4
D		
David's World	650	15
Debrief: Apollo 8	445	4
Dividends from Space – Biomedical Applications of Space Technology	643	15
Doing Something About the Weather*	659	12
Dream That Wouldn't Down	333	1
E		
Eagle Has Landed: Flight of Apollo 11 (Revised)	498	5
Earth Sun Relationship	584	11
Earthquake Below*	595	16
Earthspace	642	17
Earthspace–Our Environment	648	17
Electric Power Generation in Space	403	14
Electric Propulsion	210	14
Energy: Alternatives*	663	15
ERTS	554	16
Exploration of the Planets	526	11
Explorer to Shuttle	563	2
Extending Man's Wings	653	7
F		
Father of the Space Age	109	1
Field Trip to Space Frontiers	619	3
50th Year	443	1
Five Minutes to Live	602	15
Flight of Apollo 7	440	4
Flight of Faith 7	132	4
Flight to Tomorrow	411	13
Flight Without Wings	495	13
Flood Below*	598	17
Florida Space Coast–Profile of Progress	609	2
Fluids in Weightlessness*	607	6
Flying Machines	646	3
Four Days of Gemini 4	228	4
Four Rooms–Earth View	600	6
Fractured Look*	627	17
Freedom 7	19	4
Friendship 7	51	4
From Balloon Gondola to Manned Spacecraft	520	2
Fully Operational: STS 41-B Mission Report	689	9
G		
Gor For Sep	645	7
Great is the House of the Sun	422	16
Growing Concerns*	628	17
Gyroscopes in Space*	592	6
H		
Hazards of Tire Hydroplaning to Aircraft Operations	169	15
HEAO: The New Universe	620	11
House That NASA Built	647	15
How Did Life Begin?	78	14
Hurricane Below*	582	12
I		
If One Today – Two Tomorrow	638	12
Images of Life	629	17
J		
John Glenn Story	97	1
Jupiter Odyssey	585	11
K		
Keeping an Eye on Ginny	335	12
Knowledge Bank	524	2

*Denotes films with Lesson Guides

Title	KSC No.	Page
L		
Land for People, Land for Bears*	629	17
Launch of the Saturn V	468	5
Legacy of Gemini	395	4
Life?*	612	13
Life Beyond Earth: Mind of Man	605	2
Life on Other Planets	76	14
Live Via Satellite*	658	12
Living in Space	477	6
M		
Magnetic Effects in Space*	577	6
Magnetism in Space	608	7
Man in Space–The Second Decade	518	2
Man's Reach Should Exceed His Grasp	533	2
Mars–Is There Life?*	613	13
Mars–The Search Begins*	574	12
Mars and Beyond*	617	13
Martian Investigators*	499	12
Meals from Space	618	15
Meanwhile–Back on Earth	551	2
Mercury, Exploration of a Planet	636	11
Miles of Tiles	665	7
Mission of Apollo/Soyuz	610	3
Moon–An Emerging Planet	565	11
Moon–Old and New	512	11
Moon Flights and Medicine	555	14
N		
NASA Biosatellite Program	273	1
New Look at an Old Planet*	456	16
New View of Earth*	660	17
New View of Mars	594	13
New View of Space	552	2
Nineteen Minutes to Earth	644	13
Nuclear Propulsion in Space	422	14
O		
Opening New Frontiers	677	8
Opportunities in Zero Gravity	616	7
Orbiting Solar Observatory	93	10
Our Solar System	583	11
P		
Partners With Industry	604	15
Partnership into Space	601	2
Picture the Solar System*	662	11
Planet Mars	652	13
Poetry of Polymers	421	14
Pollution Below*	596	16
Pollution Solution?*	626	17
Portrait of Earth	670	17
Q		
Question of Life	623	13
R		
Radio Astronomy Explorer	436	10
Reach for Space	230	4
Reading the Moon's Secrets*	631	5
Regenerative Process	311	13
Rehearsal for the Moon	461	5
Remote Possibilities*	630	17
Research in the Atmosphere	523	16
Research Project X-15	354	13
Returns From Space	344	15
Round Trip Into Space	651	7
S		
Saturn Propulsion Systems	115	14
Science in Orbit	569	6
Seas of Infinity	480	11
Seeds of Discovery*	503	11
Shuttle flow at the Kennedy Space Center	690	9
Shuttle Into Space*	657	3
Skylab	534	6
Skylab–America's First Space Station	575	6
Small Steps–Giant Strides	573	2
Spacecraft Propulsion and Power	328	13
Space Expectations	571	2
Space For Women	669	3
Space in the 70's–Challenge and Promise	566	2
Space in the 70's – Space Down to Earth*	508	16
Spacelab	588	7
Spacelab–Laboratory of Tomorrow	634	7
Space Navigation	397	14
Spaceport Operations 1982	678	3
Spaceport Sanctuary	655	3
Space Research And You – Your Health*	674	3
Space Research And You – Your Home And Environment*	672	3
Space Research And You – Your Transportation*	673	3
Space Shuttle	633	7
Space Shuttle–Extra Vehicular Activity	687	9
Space Shuttle–Ground Support	685	8
Space Shuttle: Mission to Future	667	7
Space Shuttle: Overview	656	7
Space Shuttle – Propulsion	686	9
Space Shuttle–Remarkable Flying Machine	671	8
Space Shuttle – Spacelab	684	8
Space Shuttle – Transport for Tomorrow	632	7
Space Suit	478	6
Space Telescope: An Observatory in Space	666	11
Steps to Saturn	44	1
STS 51-D And 51-B Combined Mission Report	702	10
STS 51-G Launch Mission Report	703	10
STS-5 Mission Report	676	8
STS-6 Mission Report	696	9
STS-7 Mission Report	694	9
STS-8 Mission Report	683	8
STS-9 Mission Report	695	9
STS 41-B Mission Report	689	9
STS 41C Mission Report	691	9
STS 41-D Mission Report	692	9
STS 51-I Mission Report	710	10
STS 61-A Mission Report	706	10
STS-1 Postflight Press Conference	668	8
STS-2 Postflight Press Conference	679	8
STS-3 Postflight Press Conference	680	8
STS-4 Postflight Press Conference	681	8
STS-5 Postflight Press Conference	682	8
STS 41-C Postflight Press Conference	693	9
STS 51-A Postflight Press Conference	697	9
STS 51-B Postflight Press Conference	704	10
STS 51-D Postflight Press Conference	699	9
STS 51-F Postflight Press Conference	700	9
STS 51-G Postflight Press Conference	705	10
STS 51-I Postflight Press Conference	701	9
STS 61-A Postflight Press Conference	707	10
STS 61-B Postflight Press Conference	708	10
STS 61-C Postflight Press Conference	709	10
Survival	640	12

*Denotes films with Lesson Guides

Title	KSC No.	Page
T		
Technology for Spacecraft Design	309	13
Technology in Action	649	15
Technology Utilization Program	507	15
Telstar	284	12
Think Zero G	622	3
Time of the Apollo	599	5
Tip on Irons	67	16
Tornado Below*	586	12
To Worlds Beyond	388	1
Toxic Propellant Hazards	398	16
Trial Balance	319	1
U		
Universe	102	10
Using Space Resources*	664	15
U.S. Space Station Assembly Scenario	698	9
V		
View of the Sky	414	10
Voyager	688	11
W		
Weather Watchers	641	12
Wet Look*	624	17
Where Dreams Come True	654	3
Who's Out There*	587	12
Wind, Weather and Space Boosters	161	12
Within This Decade: America in Space	488	2
World Was There	603	4
X		
X-Ray Spectroscopy – The Inside Story	479	14
Y		
Your Share in Space	65	1
Youth Accepts the Space Challenge	567	6
Z		
Zero G*	591	6

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